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(54) Title: SPECIFIC THERAPEUTIC INTERVENTIONS OBTAINED BY INTERFERENCE WITH REDISTRIBUTION AND/OR TARGETING		
(57) Abstract  The application describes a novel mechanism of action, that is modulation of the specific effectiveness of I-kappa-kinases or cyclic nucleotide phosphodiesterases (PDEs) which have the ability to cleave cGMP or cAMP. The preferred mode of action is dislocation, disruption of targeting or interference with redistribution of specific isoforms or splice variants of PDE4, PDE5, or I-kappa-kinases from their anchoring sites within cells, thereby modulating their specific effectiveness, not their enzymatic capacity. The chemical entities may be useful in preventing or treating in an animal, preferably a human, in need thereof an adverse condition which may be reduced or abolished by modulating the specific effectiveness of PDE4, PDE5, or I-kappa-kinases.		

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SPECIFIC THERAPEUTIC INTERVENTIONS OBTAINED BY INTERFERENCE WITH  
REDISTRIBUTION AND/OR TARGETTING.

## SUMMARY OF THE INVENTION

This application describes a novel mechanism of action of chemical entities in order to  
5 prevent or treat adverse conditions which may be reduced or abolished by modulating  
the effectiveness of I-kappaB kinase (IKK) or cyclic nucleotide phosphodiesterases  
(PDE:s) by modulation of their targeting or localisation in the cell. The preferred mode of  
action being sought is dislocation or interference with the targeting of specific isoforms of  
IKK or PDE:s and interference with their anchoring sites within cells, thereby reducing  
10 their specific effectiveness, not directly their enzymatic capacity.

In its broadest aspect, the present application relates to a novel method for preventing or  
treating, in an animal in need thereof, an adverse condition which may be reduced or  
abolished by modulating the activity of one or more IKKs or PDE:s having the ability to  
15 cleave cAMP or cGMP. The method comprises modulation of the specific effectiveness  
of IKKs or PDE:s by modulating their spatial distribution within cells of the animal.  
The IKK is chosen from the group consisting of IKK $\alpha$ , IKK $\beta$ , IKK $\gamma$  and NIK. In one  
embodiment IKK $\beta$  is the preferred isoform. The PDE:s are chosen from the group  
consisting of PDE1, PDE2, PDE3, PDE4, PDE 5, PDE6, PDE7, PDE8, PDE9 and  
20 PDE10. More specifically, the method relates to PDE4 and isoforms thereof, such as  
PDE4D, and splice variants of PDE4D, such as PDE4D1, PDE4D2, PDE4D3, PDE4D4  
and PDE4D5. The animal with the adverse condition may be a mammal and preferably a  
human.

In one embodiment of the invention modulation of the specific effectiveness of the PDE  
25 is a dislocation of the PDE from a native location within the cell.

In another embodiment of the invention modulation of the specific effectiveness of the  
PDE involves a disruption of its targeting to a native location within the cell.

In another embodiment of the invention modulation of the specific effectiveness of the  
PDE involves interference with the redistribution of the PDE, the redistribution being  
30 associated with an increase or a decrease of the specific effectiveness of the PDE.

The modulation of the specific effectiveness of the PDE may involve both an up-  
regulation or a down-regulation of the effectiveness of the PDE to perform its function  
within the cell.

The present invention provides compositions and methods for modifying the activation of NF-kappaB by mis-targeting and/or modulation of the redistribution of specific IKKs.

In one embodiment we specifically modulate the targeting of IKK $\beta$ . We have developed  
5 two molecular probes PS473 and PS474 that upon expression in a relevant cell system  
will dislocate endogenous IKK $\beta$  from its anchoring site. The mis-targeting has, as shown  
in example 1, significant functional consequences that can be related to a diminished  
ability of cytokines and other stimuli to activate NFkappaB. We thus show that IL-1  
induced translocation of NFkappaB from cytoplasm to the nucleus is effectively inhibited,  
10 and furthermore as a consequence thereof we found that NFkappaB-induced  
transcriptional activation was inhibited.

NFkappaB has been shown to rescue transformed cells from undergoing apoptosis  
when exposed to pro-inflammatory cytokines like TNF $\alpha$  (Baichwal, V.R. & Baeuerle, P.A.  
15 (1997) Curr Biol 7, R94-6). To substantiate that mis-targeting of IKK $\beta$  is an effective way  
of blocking the functional effect of IKK $\beta$ , we analysed whether PS473 was able to  
influence TNF $\alpha$ -induced apoptosis. As seen in example 1 the probe (PS473) was found  
to hypersensitise cells to apoptotic stimuli.

20 In another embodiment the present invention provides agents that modulate the  
targeting and/or redistribution of IKKs. Such agents include polypeptides that comprise a  
putative leucine zipper region of IKK $\beta$ . Included are DNA molecules and expression  
vectors that encode for the described peptides, furthermore host cells are provided that  
express said peptides in a stable or transient expression system.

25 In another embodiment the invention provides a method for finding compounds that  
modulate targeting and redistribution of IKK $\beta$  and of derivatives thereof. The method  
renders itself to screening for compounds that modulate the functional activity of I-  
kappaB kinase  $\beta$  through modulation of one or more of multiple targeting sites of IKK $\beta$   
30 (or other IKKs) and which thereby cause either a partial or a complete inhibition of the  
NF-kappaB activation. The method will allow for identification of compounds that  
modulate said targeting or redistribution in specific cell types.

The presented novel mechanism of action will be useful in the treatment of the following  
35 diseases/conditions: chronic inflammation, asthma and chronic bronchial hyperreactivity

of non-asthma etiology, rheumatoid arthritis and pelvispondylitis, ulcerative colitis and Crohn's disease, diabetes mellitus type I, systemic lupus erythematosus, myasthenia gravis, Hashimoto's thyroiditis, Graves' disease and immune thrombocytopenic purpura, acute respiratory distress syndrome (ARDS) and septic shock as well as  
5 depression.

## Background

Chronic inflammation is the result of unbalanced and continued production of  
10 inflammatory cytokines. Cytokines are produced in cascades, the pro-inflammatory  $\text{TNF}\alpha$  and  $\text{IL-1}\beta$  often responsible for initiating a process, which leads to a more general production of further cytokines. This cascade of gene expression is largely under the control of NF-kappaB, a ubiquitous transcription factor that, by regulating the expression of multiple inflammatory and immune genes, plays a critical role in host defence and in  
15 chronic inflammatory diseases (Sen and Baltimore, 1986; Mukaida *et al.*, 1990; Beg *et al.*, 1993; Cogswell *et al.*, 1993). NF-kappaB is activated not only by cytokines, but also by reactive oxygen species (ROS), viruses, and a range of other generally noxious and pathogenic stimuli (Blackwell *et al.*, 1997; Schulzwe-Osthoft *et al.*, 1997). Activation of NF-kappaB via ROS has been implicated in neurodegenerative disorders such as  
20 Parkinson's and Alzheimer's (Lesoualc'h *et al.*, 1998; O'Neill *et al.*, 1997) and also in inflammatory bowel disease (Jourdain *et al.*, 1997). Tissue inflammatory response to x-rays is mediated directly by NF-kappaB (Hallahan *et al.*, 1995). Activation of NF-kappaB has been implicated in the production of atherosclerotic lesions of smooth muscle cells (Bourcier *et al.*, 1997) and in cardiac inflammatory disorders (Hattori *et al.*, 1997). NF-  
25 kappaB/Rel transcription factors are also known to play a role in the pathogenesis of certain tumours, especially those of haematopoietic origin (Neumann *et al.*, 1997), and constitutive (autocrine) activation of NF-kappaB is known to promote a resistance to apoptotic stimuli (Giri *et al.*, 1998). Inhibitors of NF-kappaB should increase the cytotoxic efficacy of anticancer chemotherapies (Bours *et al.*, 1998).  
30 The inflammatory pathways are notoriously complex, yet the feasibility of reducing or eliminating inflammatory responses through modulation of NF-kappaB activity has already been demonstrated in a number of different cells (Makarov *et al.*, 1997).

The NF-kappaB/Rel group of transcription activators and their co-evolved regulatory  
35 proteins, the inhibitors of kappa B (I-kappaBs), play important roles in many cellular

- signalling processes in vertebrates, which include controlling communication between cells, embryo development, maintenance of cell type specific expression of genes as well as co-ordinating the inflammatory response to stressors and viral infection (Wulczyn *et al.*, 1996). The key proteins involved in this control system divide into distinct groups:
- 5 a) Those that bind DNA. These belong to the Rel family of transcription factors (Ghosh *et al.*, 1990) and include p50, p65, p52/49, p75/Rel and RelB. Only dimers bind DNA, but these can be homodimers or heterodimers. p65/p50 heterodimer is the most abundant, and plays a more elaborate role than other factors in regulating gene expression (Baldwin, 1996).
  - b) Those that interact with the DNA-binding subunits in cytoplasm,
  - 10 which include the inhibitory I-kappaB $\alpha$  and I-kappaB $\beta$  molecules (Bauerle and Baltimore, 1988), and the precursor molecule p105 (Naumann *et al.*, 1993).
  - c) Those transcriptional coactivators which interact with the DNA-binding subunits in the nucleus, such as Bcl3 (Nolan *et al.*, 1993; Watanabe *et al.*, 1997) and Cbp/p300 (Zhong *et al.*, 1998).
  - d) Kinases which activate proteasomal destruction of I-kappaB $\alpha$  and  $\beta$  subunits - the I-
  - 15 kappaB kinases (Beg *et al.*, 1993).
  - e) Kinases which directly phosphorylate the DNA-binding subunits in cytoplasm and nucleus to modulate their activity, such as PKA (Zhong *et al.*, 1998), casein kinase II (Bird *et al.*, 1997) and others (Hayashi *et al.*, 1993; Schulze-Osthoff *et al.*, 1997).
  - 20 Inactive p65/p50 NF-kappaB dimers are held in the cytoplasm coupled to inhibitory I-kappaB molecules ( $\alpha$  and  $\beta$  isoforms) via the p65 subunits. Activated I-kappaB kinases (IKK) phosphorylate the inhibitors, targeting them for ubiquitination and subsequent proteasomal digestion (Beg *et al.*, 1993). The released subunits translocate to the nucleus and there activate transcription.
  - 25 The I-kappa kinases (IKK- $\alpha$ , IKK- $\beta$  and IKK- $\gamma$ ) have been shown to be part of a large multi-component complex (Chen *et al.* 1996; Rothwarf *et al.*, 1998). It is likely to assume that the assembly and disassembly of the IKK complex is controlled by a scaffold protein termed IKK-complex-associated protein, IKAP (Cohen *et al.* 1998). It is expected that a tight assembly of the complex is necessary for the IKKs to be activated by the NF-kappa-
  - 30 B-inducing kinase (NIK) and thereby induce phosphorylation of the I-kappaB subunits. Interestingly the affinity of IKK- $\beta$  for IKAP diminishes upon phosphorylation of IKK- $\beta$  by NIK.

Glucocorticoids (GC) are powerfully efficient modulators of inflammation, but suffer from  
35 the potential hazards of suppressing necessary protective responses to infection and

decreasing some essential healing processes. They modulate cytokine expression by a combination of genomic mechanisms. The activated GC-receptor complex can (i) bind to and inactivate AP-1 or NF-kappaB, (ii) upregulate I-kappaB production via GC response elements (iii) reduce the half-life of cytokine mRNAs (Brattsand & Linden 1996). But  
5 steroid treatment broadly attenuates all cytokine production from all lymphocytes, so not only do levels of the inflammatory cytokines fall, but also that of the anti-inflammatory IL-10. Specific modulation of Th1-type pathways would be an initial goal of this project. It is also known that some fibroblast cell NF-kappaB-mediated responses are likely governors of inflammatory progression, so inhibition of such responses could have  
10 detrimental effects (Smith et al., 1997). Therapies, which maintain appropriate feedback systems, but modulate inappropriate cytokine production represent an unmet medical need.

An attractive therapeutic intervention to be used in the treatment of chronic inflammatory  
15 conditions is inhibition of the I-kappaB degradation. Blocking the ubiquitin proteasome pathway (PharmaProjects, Accession no. 023654 and 027675), can directly inhibit this degradation. Another mechanism that is being pursued is inhibition of the enzymatic activity of either of the IKKs or NIK (public statement from Signal Pharmaceuticals).

20 Very many extracellular signals are transduced via intracellular systems employing the cyclic nucleotides cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate (cGMP) as intermediaries, or second messengers. The processes mediated by cAMP and cGMP include control of smooth muscle tone, learning, vision, cellular differentiation, control of pro-inflammatory mediator production and action,  
25 apoptosis, lipogenesis, glycogenolysis and gluconeogenesis, circadian rhythms, cardiac function, and mood control through noradrenergic potentiation.

Cyclic nucleotides are generated by adenylate and guanylate cyclases (ACs and GCs, respectively) from ATP and GTP, signal to cAMP- and cGMP-dependent effector proteins such as protein kinases (cAKs and cGKs, respectively) and certain ion  
30 channels. cAMP and cGMP are removed by phosphodiesterases (PDE:s). The required specificity of signals generated by these systems arises from diversity of type, tissue-specific expression and intracellular placement of the enzymes involved. For instance there are nine isoforms of ACs known plus additional splice variants, soluble and membrane located forms of GCs, multiple isoforms of the cAK and cGK kinases, and  
35 very many isoforms of PDE:s of which over 30 have been identified (Perry and Higgs, 1998; Houslay and Milligan, 1997; Beavo, 1995). Additional specificity arises from

targeting particular signalling enzymes to restricted locations within cells; this is the function of scaffold and anchoring proteins, such as the AKAP family, and not only may they place enzymes close to their substrates, but they may also serve to recruit multiple enzymes into functional signalling units (Pawson and Scott, 1997).

- 5 Inactivation of cAMP/cGMP occurs by hydrolysis of the 3'-ester bond, catalysed by the PDEs. The PDE:s are key components of the cyclic nucleotide signalling systems, allowing local concentration differences of the cyclic nucleotide messengers to be established, between adjacent tissues, between adjacent cells, even within a single cell between different volumes of cytoplasm. The ability to generate such heterogeneity in  
10 the distribution of concentrations of a commonly shared signalling molecule, such as cAMP, is at the heart of directed signalling processes. To be of therapeutic value, cyclic nucleotide control has to be achieved with defined cellular selectivity (Perry and Higgs, 1998). It is the therapeutic opportunities offered by certain of the PDE:s that concerns this application.

- 15 Ten families of PDE:s have been identified, designated simply PDE1 to PDE10. Within each family there are two or more related but distinct gene products (A, B, C, etc.) and for each of these alternative mRNA processing gives rise to multiple splice variants, identified by an additional arabic numeral in accordance with the most recent nomenclature recommendation (Molecular Pharmacology 46:399-405, 1994). All PDE  
20 gene products identified so far have two functional domains per molecule, one catalytic, and one regulatory. The catalytic domain lies towards the carboxylic acid terminus of each PDE protein and has the greatest homology between the PDE families, being >75% homologous at the amino acid level (Perry and Higgs, 1998). Nevertheless, each of the more than 30 PDE:s known have individually distinct substrate specificities, kinetic  
25 characteristics, regulatory properties and cellular and subcellular distributions (Houslay and Milligan, 1997).

- PDE:s 4, 7 and 8 are highly specific for cAMP. PDE:s 5, 6, 9 and 10 are selective for cGMP. PDE3s bind cAMP and cGMP with similar affinity, but hydrolyse cAMP most efficiently, cGMP rather poorly. PDE3s are therefore negatively regulated in their cAMP  
30 hydrolysing ability by cGMP. PDE:s 1 and 2 hydrolyse both cAMP and cGMP, but with PDE1 the relative efficiencies vary with isoenzyme subtype (Perry and Higgs, 1998).

- The amino terminal ends of PDE:s consist of the regulatory domains, which are very different both between families and between variants within families. This region contains variously: a binding domain for  $\text{Ca}^{2+}$ -calmodulin (CaM) in PDE1; non-catalytic cGMP-  
35 binding sites in PDE:s 2, 5 and 6; a binding domain for the signalling G-protein

transducin in PDE6. The amino terminal region also contains protein- and membrane-targeting sequences in several PDE3:s and PDE4:s, as well as protein kinase phosphorylation sites in PDE:s 1, 3, 4 and 5. These phosphorylation sites are likely to be important in regulation of catalytic activity and/or subcellular location (Perry and Higgs, 5 1998).

Amongst the cAMP degrading phosphodiesterases, we focus here on the largest and most diverse family known, the PDE4:s. PDE4 enzymes share a common structure, as deduced from their amino acid sequences (Beavo and Reifsnnyder, 1990; Bolger *et al.*, 10 1993, Houslay, Sullivan and Bolger, 1998). Members of each gene family (PDE4A, PDE4B, PDE4C, PDE4D) share common C-terminal regions, different for each family, and catalytic domains that for all PDE4 isoforms are very similar (84% homology over about 360 amino acids across all PDE4:s; Houslay, Sullivan and Bolger, 1998). From N-terminus to catalytic region, the sequence in "long form" PDE4s can be divided into 5 15 regions, three of which are isoform-specific (N-terminal region, linker regions 1 and 2, or LR1 and LR2) and two, more conserved regions, that are broadly similar between all isoforms, the upstream conserved regions 1 and 2 (UCR1 and UCR2). "Short form" PDE4:s, e.g. PDE4A1, PDE4B2, PDE4D1, PDE4D2, lack UCR1 and LR1 plus differing amounts of the N-terminal region of UCR2. Throughout all regions are potential 20 phosphorylation sites for a variety of kinases, including PKA (e.g. Ser 54 in human PDE4D3), mitogen activated protein kinases (e.g. Ser 487 of human PDE4B2), casein kinase II (e.g. Ser 489 of PDE4B2) and calcium-diacylglycerol dependent protein kinases (Houslay, Sullivan and Bolger, 1998). Phosphorylations at some of these sites have been shown to activate the PDEs (e.g. Ser 54), others serve to inhibit. There is also 25 evidence that some phosphorylations serve to prime the enzymes ready for subsequent activation by further phosphorylation at a different site or sites (Houslay, Sullivan and Bolger, 1998). Other auto-regulatory sites may be found in the N-terminal sequence of certain PDE4:s (Bolger *et al.*, 1996, McPhee *et al.*, 1995).

The identification of rolipram (Schering AG, Berlin, Germany) as an effective inhibitor of 30 PDE4:s (Wachtel, 1982, Nemoz *et al.*, 1985) gave an important tool by which to determine the role of PDE4:s in different cell types. Originally developed as a neurotropic agent, rolipram indicated the therapeutic potential of PDE4 inhibition in control of depressive disorders. Analysis of the pharmacological properties of rolipram, and over 800 publications covering these properties have appeared over the period 1993 to 1998 35 alone, now indicates that specific PDE4 inhibition may be useful over a very wide range of disease areas. These include: asthma, atopic dermatitis, depression, reperfusion

injury, septic shock, toxic shock, autoimmune diabetes, AIDS, Crohn's disease, multiple sclerosis, cerebral ischemia, psoriasis, allograft rejection, restenosis, ulcerative colitis, cachexia, cerebral malaria, allergic rhinoconjunctivitis, osteoarthritis, rheumatoid arthritis, autoimmune encephalomyelitis (Houslay, Sullivan and Bolger, 1998).

- 5 In the area of asthma, PDE4 inhibition helps to increase cAMP in bronchial smooth muscle, thereby producing a modest bronchodilatory effect, of use in the alleviation of asthmatic symptoms. But perhaps most importantly, inhibition of PDE4:s is now a recognised method by which to suppress immune and inflammatory cell responses (Hughes *et al.*, 1997; Torphy, 1998; Teixeira *et al.*, 1997).
- 10 PDE4:s play major roles in modulating the activity of virtually every cell type involved in the inflammatory process. Immune and inflammatory conditions occur when recruitment of leukocytes from the blood compartment into tissues is either uncontrolled, inappropriate, prolonged or directed against self. In asthma, rheumatoid arthritis and multiple sclerosis, infiltration of tissues with inflammatory cells is prolonged and intense,
- 15 leading ultimately to severe (and self-perpetuating) damage and loss of function. Acute dysregulation of the immune system occurs in such conditions as acute respiratory distress syndrome (ARDS) where an overwhelming and generalised inflammatory response can frequently lead to death. There is also substantial evidence which suggests that inflammation may play a part in defining the extent of injury resulting from
- 20 reperfusion following ischaemia, at least in brain and lung (Entman and Smith, 1994). Chronic inflammatory conditions such as asthma are currently treatable with steroids, but long term treatment brings unavoidable side-effects including immunosuppression, metabolic disturbance and hypertension (Teixeira *et al.*, 1997). Symptoms of rheumatoid arthritis can be alleviated by non-steroidal anti-inflammatories (NSAIDs), but again their
- 25 side effects are of great concern. Acute conditions such as ARDS have no current treatment as such, only supportive care. Effective anti-inflammatories able to control dysregulated responses, but without the side effects associated with NSAIDs and steroids, have not yet been found.

Within the context of asthma, elevation of intracellular cAMP by PDE inhibition has been

30 associated with inhibition of the function of various types of cells involved in the inflammatory response, including lymphocytes, monocytes, macrophages, neutrophils, eosinophils, mast cells, basophils, endothelial cells and lung epithelial cells (Nicholson and Shahid, 1994); PDE4:s appear to play the dominant role in neutrophils, basophils, eosinophils and mast cells, PDE3s being dominant in monocytes/macrophages and

35 lymphocytes. Inhibitors of PDE3s and PDE4:s often interact synergistically in control of

inflammatory response in asthma models (Teixeira *et al.*, 1997). Other PDE:s may be important in inflammatory cells, but their involvement has yet to be clarified or demonstrated.

Increased cAMP modulates myosin light chain kinase (MLCK) activity causing relaxation, and this is the primary effect in bronchial smooth muscle. Useful compounds will relax bronchial smooth muscle slowly and maintain relaxation for sustained periods, but also help reduce inflammatory immune responses to allergens. Although a combined inhibition of PDE3 and PDE4 isozymes seems to relax bronchial smooth muscle most effectively (Raeburn & Advenier, 1995) in humans, the possibility of cardiovascular complications is increased by the use of PDE3 inhibitors, and in fact PDE4 inhibitors such as rolipram, alone or in combination with agonists of the  $\beta_2$  adrenoceptors such as salbutamol, are effective bronchorelaxants.

Possible mechanisms (Teixeira *et al.*, 1997) involved in the anti-inflammatory benefits of PDE4 inhibition *in vivo* include:

- 15 - Inhibition of the production and release of inflammatory mediators/cytokines.
  - Inhibition of leukocyte migration.
  - Induction of cytokines with suppressive activity.
  - Inhibition of leukocyte activation (degranulation, respiratory burst).
  - Inhibition of the expression/upregulation of cell adhesion molecules.
- 20 - Induction of apoptosis amongst inflammatory cells.
  - Also, stimulation of endogenous steroid and catecholamine release (Pettipher *et al.*, 1996).

Perhaps the most important consequence *in vivo* of selective PDE4 inhibition may be to inhibit chemokine production, especially those that are chemoattractants of leukocytes (Teixeira *et al.*, 1997). Inhibitors of PDE4 are effective suppressers of cytokine production *in vitro* and reduce serum levels of tumor necrosis factor alpha (TNF- $\alpha$ ) in animal models of septic shock (Sekut *et al.*, 1995; Pettipher *et al.*, 1996; Prabhakar *et al.*, 1994). Inhibition of TNF- $\alpha$  production may be central to the beneficial effects of PDE4 inhibition in treatment of inflammatory conditions, but inhibition of the release of chemoattractants such as the  $\alpha$ -chemokine interleukin-8 and the lipid leukotriene (LT) $B_4$  may also be important for reducing leukocyte recruitment to sites of inflammation (Turner *et al.*, 1994; Griswold *et al.*, 1993).

It is also known however that there are protective effects of PDE4 inhibition which are quite separate from inhibition of release and action of TNF- $\alpha$  and other pro-inflammatory mediators. At higher concentrations than are necessary to inhibit TNF- $\alpha$  release,

rolipram appears to have a direct effect on eosinophils (Teixeira *et al.*, 1994) and eosinophilia. PDE4 inhibition also stimulates macrophages to produce and release the antiinflammatory cytokine interleukin 10 (IL-10) when challenged with lipopolysaccharide (LPS) *in vitro* (Kambayashi *et al.*, 1995; Jilg *et al.*, 1996), and this same effect may be involved in the protective action of methylxanthines, which are general PDE inhibitors, in a murine model of septic shock (Jilg *et al.*, 1996).

Inhibition of neutrophil activation *in vivo* may also be how PDE4 inhibition protects against acute lung injury induced by LPS followed by zymosan in a murine model (Miotla *et al.*, 1995), and in animal models of asthma, it is likely that PDE4 inhibition suppresses allergic inflammation by inhibition of eosinophil activation together with inhibition of mast cell de-granulation (Hughes *et al.*, 1996).

PDE4 inhibition has also been shown to affect the *in vitro* expression and presentation of cell adhesion molecules such as E-selectin by endothelial cells of the microvasculature (Blease *et al.*, 1998; Mörandini *et al.*, 1996) and increased cAMP also prevents mediator-induced upregulation of  $\beta 2$  integrins on the surface of eosinophils and neutrophils (Teixeira *et al.*, 1996). Inhibition of the cell adhesion components responsible for recruitment of leukocytes and for initiation of tissue infiltration by the inflammatory cells is an important aspect of therapeutic control for inflammatory conditions.

cAMP-elevating agents also enhance apoptotic clearance of various leukocytes *in vitro* (Hallsworth *et al.*, 1996), and this too may be useful effect in the control of inflammation through PDE4 inhibition.

The major cGMP-degrading PDEs are types 1,2,5, 6, 9 and 10 but here we focus on PDE5, since this is the principal cGMP-specific PDE found in airway and vascular smooth muscle, and it is one of the better documented families of cGMP-specific PDEs. Little is known yet concerning the role of the newly discovered PDE9 and PDE10 isoforms (Soderling *et al.*, 1998; Fisher *et al.*, 1998; Soderling *et al.*, 1999; Fujishige *et al.*, 1999), and the situation is similar for PDE2s, since good inhibitors are as yet unknown for these (Perry and Higgs, 1998). PDE5 is activated by cAK and (10-fold faster) by cGK (Thomas *et al.*, 1990). Phosphorylation of PDE5 is enhanced in the presence of cGMP, and apparently increases the enzyme's  $V_{max}$  by 10-fold (Burns *et al.*, 1992). Coupled with PDE3, these interactions form a feedback system to limit cGMP signaling: increased cGMP will increase cAMP through inhibition of PDE3, high cAMP will activate cAK which, in the presence of elevated cGMP will activate PDE5 and therefore stimulate cGMP breakdown. cAMP levels return to baseline as cGMP falls, by re-activation of PDE3. Recent evidence (Pyne *et al.*, 1996; Lochhead *et al.*, 1997)

- suggests that PDE5 may have additional protein components associated with it analogous to the gamma subunits of PDE6. The PDE6 $\gamma$  subunits serve to link activation of the G-protein transducin to activation of the PDE. They are subsequently involved in turning off the signal by helping to activate the transducin GTPase. In the case of PDE5, these associated proteins (14 to 18 kDa) may serve to block activation of the enzyme by cGK and cAK, and the blocking ability of these polypeptides appears to be controlled by a G-protein regulated kinase (Pyne *et al.*, 1996).
- cGMP-degrading PDEs work in concert with the action of guanylate cyclases, just as cAMP PDEs and adenylate cyclases together control cAMP levels in cells. Two groups of GCs are known in mammals, the soluble ones and those that are membrane located. GCs from both groups are central to systemic control of blood pressure. Soluble GCs are expressed in almost all cell types of the cardiovascular system including cardiomyocytes, vascular smooth muscle cells (VSMCs), endothelial cells and platelets (Drewett and Garbers, 1994). Soluble GCs contain a prosthetic heme group which binds NO (and CO) and leads to activation of the enzyme: the vasoactive properties of NO are mediated through the cGMP pathway in this way. The membrane located GCs act as receptors for various ligands (among them, natriuretic peptides and guanylin). cGMP-mediated functions of the natriuretic hormone receptors include vascular smooth muscle relaxation as well as regulation of blood volume (Benner *et al.*, 1990).
- cGMP interacts with a number of different effector proteins:
- a) with certain ion channels e.g. in photoreceptors and olfactory cells, also in heart and kidney (Lincoln & Cornwell, 1993; Biel *et al.*, 1994; Light *et al.*, 1990);
  - b) with cGMP-dependent protein kinases (cGKI and cGKII), of which "cytosolic" cGKI predominates in the cardiovascular system and has at least 2 splice variants,  $\alpha$  and  $\beta$ . cGKI $\alpha$  has 10-fold higher affinity for cGMP than the  $\beta$  variant. Both cGKI variants are found in vascular smooth muscle (Keilbach *et al.*, 1992; Hofmann *et al.*, 1992);
  - c) at high concentrations, with cAMP-dependent protein kinases (cAK), which being similar to the cGKs have a certain affinity for cGMP, just as the reverse is also true (Vaandrager & de Jonge, 1996). The functional significance of this potential cross-talk between pathways is not yet fully known, but may be connected with the anti-proliferative effects of cGMP (Lincoln *et al.*, 1994);
  - d) with cGMP-modulated PDEs: cGMP binds to a non-catalytic site of PDE2 and lowers its  $K_m$  for cAMP, lowering the baseline level of cAMP achievable by the enzyme. PDE3 catalysis of cAMP is effectively inhibited by cGMP (Pyne *et al.*, 1987), thus in cells where PDE3 predominates, increased cGMP leads to increased cAMP.

Smooth muscle contracts following  $\text{Ca}^{2+}$ -calmodulin activation of myosin light chain kinase (MLCK). cGKI relaxes smooth muscle by lowering free cytoplasmic  $\text{Ca}^{2+}$  levels, but the principal means by which this is accomplished varies considerably between types of smooth muscle, animal species, and the nature of the contractile stimulus being

5 antagonised (Vaandrager & de Jonge, 1996). cGKI has been implicated in: inhibition of G-protein activation of phospholipase C  $\beta$ ; activation of  $\text{Ca}^{2+}$ -ATPase activity at plasma membrane and sarcoplasmic reticulum (SR); hyperpolarisation of membrane potential through activation of  $\text{Ca}^{2+}$ -activated  $\text{K}^+$  channels; inhibition of voltage operated  $\text{Ca}^{2+}$  channels; stimulation of the  $\text{Na}^+/\text{Ca}^{2+}$  exchanger; inhibition of SR  $\text{IP}_3$  receptors. All of

10 these actions require that the normally cytoplasmic cGKs must find membrane located targets, and specific anchor proteins may be involved. cGKI is already known to be targeted to specific anchor proteins of the cytoskeleton (MacMillan-Crow & Lincoln, 1994), and the discovery of further interactions is likely.

Blood pressure elevation to a degree that requires medical treatment is often

15 encountered in up to 15% of an adult population. In only 10-15% of these, a definite cause for the hypertension can be found and in the rest, the "essential hypertension" has to be treated without a hope for cure of the underlying disease. Long-standing elevation of blood pressure, even quite moderate, damages vessels in the heart, kidneys and brain and dramatically increases the risk for coronary heart disease, renal failure and

20 stroke. It has been shown that effective pharmacologic treatment of hypertension substantially reduces morbidity and mortality from these conditions. The finding that endothelial cells produce a local vascular relaxation factor, identified as nitric oxide (NO), that activates guanylyl cyclase and increases cGMP that in turn leads to reduction in vascular smooth muscle cell tone, has opened new possibilities for blood pressure

25 regulation / vasorelaxation based on modulation of the cellular levels of cGMP. A number of the components in the cGMP system displays tissue specific distribution (Vaandrager & de Jonge, 1996; Pyne *et al.*, 1996). This increases the likelihood for improved pharmacological specificity and fewer side-effects when using these as targets for antihypertensive treatment instead of the traditional ones. It is the cGMP-dependent

30 protein kinase (PKG) (Vaandrager & de Jonge, 1996) that is thought to mediate the intracellular effects of cGMP. The cGMP -dependent and -specific phosphodiesterases can serve as connectors to the cAMP system and terminators of cGMP effects (Pyne *et al.*, 1996).

PDE5 has attracted attention since it is selective for degradation of cGMP versus cAMP.

35 Isoform-specific inhibitors for PDE5 are being developed by several companies and one

compound from Pfizer, Sildenafil, has proven selectivity for PDE5 and is currently being marketed as treatment against impotence (Viagra), originally a side-effect resulting from vasorelaxation in the corpus cavernosum. However the screening procedures currently used search only for direct enzymatic inhibitors of PDE and the compounds found are  
5 often not selective, inhibiting for instance both PDE 1 and 5 (e.g. Zaprinast (M&B 22948 RPR), Sch 59498 and Sch 51866). By the methods described herein and within appendix A, new chemical entities can be found which primarily will be specific modulators of PDE action, not inhibitors of the enzymatic action *per se*. Preferred compounds will inhibit the site-specific anchoring of PDEs which hydrolyse cGMP, and  
10 thereby reduce their effectiveness in controlling local concentrations cGMP within living cells.

The therapeutic potential of selective modulators of cGMP-related PDE action is not restricted to relaxation of smooth muscle cells but also encompasses other effects ascribed to PKG, such as inhibition of platelet activation (Chiu *et al.*, 1997; Vemulapalli  
15 *et al.*, 1996), inhibition of endothelial permeability increases in response to vasoactive substances (Raeburn & Karlsson, 1993), inhibition of the differentiation of osteoclasts (Holliday *et al.*, 1997) and light-induced resetting of circadian rhythms (Mathur *et al.*, 1996; Liu *et al.*, 1997).

20 The search for chemical inhibitors of the catalytic activity of specific PDE:s is currently one of the most intensive areas of pharmaceutical research, particularly so for PDE:s 4 and 5. Much progress has been made in this area, with several compounds known to have selective activity for particular families of PDE:s (reviewed in Perry and Higgs,  
25 1998; Hughes *et al.*, 1997; Teixeira *et al.*, 1997). However, there has not yet been found a class of compounds able to select between isoenzymes within the same family, which is where the greatest opportunities lie. Without isoform specificity, certain difficulties can be expected with the use of enzymic inhibitors of PDE:s. Some of these difficulties are outlined below.

30 In general, the effects a known inhibitor of the catalytic activity of a particular class of PDE:s may have on cyclic nucleotide levels often varies between different cell types. The reasons for this are several, but include: differences in the basal level of cyclase activity in distinct cell types, crosstalk between cAMP and cGMP systems, and differences in  
35 local concentrations of substrate within a cell which influences the degree of inhibition that can be attained by a simple competitive enzyme inhibitor (Perry and Higgs, 1998).

First, PDE inhibition is only useful if it produces the appropriate change in the activity of the dependent effectors, for instance activation of cAK when the concentration of cAMP can be increased above a threshold level. The rate of change in concentration depends in part on the activity of the cyclases which generate the cyclic nucleotides, and that  
5 basal level of activity differs from isoform to isoform, and therefore from cell type to cell type. In adipocytes, for example, AC activity is high and cAMP levels are kept at baseline only by a correspondingly high PDE activity. Hepatocytes on the other hand have a rather low AC activity. If both cell types share PDE:s of the same family, and are treated with a chemical inhibitor targeting that family, there will be a rapid increase in cAMP  
10 within adipocytes and activation of their cAKs, but no activation in hepatocytes, unless the AC is also stimulated.

Second, general inhibition of a particular isoform of PDE can have certain unavoidable consequences on other cyclic nucleotide pathways since cAMP and cGMP systems are often closely interlinked. Much of this crosstalk arises from PDE regulation by cyclic  
15 nucleotides. When cGMP increases in platelets (e.g. following nitric oxide stimulation of soluble GC, or PDE5 inhibition) it inhibits PDE3 and causes a concomitant rise in cAMP (Ashida and Sakuma, 1992). In adrenal glomerulosa cells, atrial natriuretic factor elevates cGMP but inhibits cAMP-stimulated aldosterone synthesis via cGMP-stimulation of PDE2 (MacFarland *et al.*, 1991).

20 Third, the expected effects of PDE inhibition may be modified by differences in local concentrations of substrates, the reason being that most chemical inhibitors of PDE action are competitive with substrate, so their therapeutic profile is dependent on both the Michaelis-Menton equilibrium constant ( $K_M$ ) and the substrate concentration in which they are operating (Perry and Higgs, 1998). Most effective inhibition will always occur at  
25 lowest substrate levels, but as a corollary, a locally increased substrate level will reduce the inhibition attained. In combination with subtle differences in isoform  $K_M$  values for an inhibitor, the desired spatial modulation of cyclic nucleotide levels within a cell could be difficult to obtain by simple competitive inhibition of catalytic activity.

Fourth, there is increasing evidence that cells respond to the prolonged use of agents  
30 that increase cyclic nucleotide concentrations by increasing the activity of endogenous levels of appropriate phosphodiesterases (Torphy *et al.* 1995), and that one class of mechanism whereby this occurs is by increasing expression levels of PDE proteins (Swinnen *et al.*, 1989, 1991). There is even evidence to suggest that the use of selective inhibitors of different PDE families (eg rolipram for PDE4:s, cilostimide for PDE3,  
35 zaprinast for PDE5 etc.), encourages cells and tissues to respond to catalytic inhibition

by upregulating PDE:s specifically of the family type that is under inhibition. Full catalytic inhibition of PDE:s may therefore have self-defeating results, as cells attempt to compensate for lack of specific PDE activity. Careful modulation of local cyclic nucleotide levels within a cell through dislocation or inhibition of redistribution, which may not  
5 greatly affect global levels of cyclic nucleotide, may therefore prove to be a better and more effective means to achieve long term therapy.

The radically different methods of interference with PDE action as proposed below in this application should avoid many of the problems outlined above, principally because  
10 interference will be family and isoform specific and targeted not against catalytic activity of the PDE:s, but their spatial organisation within the cell.

Targeting of signalling enzymes is a recognised mechanism by which sensitivity, specificity, precision and control may be introduced into intracellular signalling pathways  
15 (Pawson and Scott, 1997; Faux and Scott, 1996). The importance and occurrence of targeting as a phenomenon are described and discussed in appendix A. Of central importance to this application is the modulation of the effectiveness of signalling PDE:s through interference with their intracellular targeting. As already described, the many PDE:s known share much structural homology, and this is especially true within the  
20 catalytic regions found towards the carboxylic acid terminals of the proteins. At the amino terminals much more heterogeneity is found, between families of PDE:s, between isoforms within families, and between splice variants derived from individual gene isoforms (Houslay and Milligan, 1997). Much of this heterogeneity appears to be associated with differences in targeting behaviour, at least in PDE4 isoforms and  
25 variants (Scotland *et al.*, 1998, Bolger *et al.*, 1997), and by extension should apply to other PDEs as well since they are in overall character similar protein molecules with similar roles in cellular signalling.

Evidence suggests that the amino terminal regions of PDE:s can serve to target isoforms to specific intracellular sites (Shakur *et al.*, 1995; McPhee *et al.*, 1995; Bolger *et al.*,  
30 1996; Pooley *et al.*, 1997) and that they can regulate the functioning of the catalytic unit either through interaction with binding proteins (Shakur *et al.*, 1995; O'Connell *et al.*, 1996; Pyne *et al.*, 1996) or through phosphorylation (Sette and Conti, 1996). Targeting appears to occur through protein-protein interactions with membrane- or cytoskeletally-located proteins (Houslay, Sullivan and Bolger, 1998), and of these the membrane  
35 associated proteins include both integral and peripherally adherent species. Such

interactions have been probed at a gross level through the use of nonionic detergents and elevated ionic strength (Scotland *et al.*, 1998).

- Four separate genes are known to produce PDE4:s in human and rat (PDE4A-D), and each of these produces multiple splice variants (more than 20 described to June 98),
- 5 many with unique amino terminal regions (Huston *et al.*, 1997; Bolger *et al.*, 1997; Obernolte *et al.*, 1997). Some variants have extensive deletions, even to the point of removing catalytic activity (Obernolte *et al.*, 1997). Differences in the amino terminal regions are presently contemplated to be important for determining differences in the subcellular localisation, activity and sensitivity to inhibitors amongst PDE4 isozymes
- 10 (Bolger, 1997; Scotland *et al.*, 1998). As an example, PDE4D1 and PDE4D2 are found only in cytosolic fractions, PDE4D3, D4 & D5 are all represented in both cytosolic and particulate fractions. PDE4D3 and D5 are both more sensitive to rolipram inhibition in the cytosolic phase than they are in the particulate fraction (Bolger *et al.*, 1997). Of the 3 "B" isozymes, PDE4B2 is approximately 10 fold more sensitive to rolipram in the particulate
- 15 fraction than in the cytosolic (Huston *et al.*, 1997). Certain PDE4 isozymes are known to have restricted tissue distributions, e.g. PDE4A8 and PDE4C-delta54 are found only in testis, PDE4C-791 in lung and a melanoma cell line G361 (Bolger *et al.*, 1996; Obernolte *et al.*, 1997). In other cells the expression of isozymes changes with cellular differentiation (Verghese *et al.*, 1995; Giorgi *et al.*, 1997; Bolger *et al.*, 1994; Essayan *et*
- 20 *al.*, 1997).

- Certain PDE4 isozymes are known to associate with membranes, some with proteins bearing SH3 domains, and some to be purely cytosolic (Scotland *et al.*, 1998; Bolger *et al.*, 1997). A variant of PDE4A ("RD1") transfected into human thyroid carcinoma lines accumulates specifically in Golgi, and at the same time inhibits all expression of "native"
- 25 PDE1 in those cells (Pooley *et al.*, 1997). These distinct locations are believed to reflect very different functions of the specific phosphodiesterases. A very clear demonstration of functional separation of PDE:s has been seen in renal mesangial cells. Immuno-inflammatory stimulation of these cells increases their production of reactive oxygen metabolites (ROM) and simultaneously increases proliferation. Specific inhibition of
- 30 PDE4 suppresses ROM production, but not proliferation. Specific inhibition of PDE3 inhibits proliferation but not ROM production (Chini *et al.*, 1997). Both responses are mediated by PKA but control of the cAMP pool is effectively separated.
- Location of PDE:s to membranes brings them into contact with phospholipids. Certain PDE4 isozymes are activated by anionic phospholipids such as phosphatidyl serine and

- phosphatidic acid (Disanto *et al.*, 1995; Nemoz *et al.*, 1997). Dislocation from the membrane will inhibit such activation, and crosstalk with phospholipid signalling systems. Targeting or anchoring of PDE4:s is likely to have its greatest effect through compartmentalisation of cAMP signalling within cells (Houslay and Milligan, 1997).
- 5 Associated with the PDE4:s will be specific ACs together with specific isoforms of the effector cAK, or cAMP-operated ion channels. cAKs will likely be attached to specific AKAPs (A-kinase anchoring proteins). Specific subcellular distributions of these components have been mapped in cells (Houslay and Milligan, 1997; Scott and Pawson, 1997; Coghlan *et al.*, 1995) and allow for spatial and temporal gradients of cAMP to be
- 10 established within cellular compartments. Targeted PDE4 species might serve to control threshold levels of cAMP in the environs of specific cAK molecules, perhaps protecting certain protein complexes from cAK-mediated phosphorylation or manipulating the activity levels of ACs that are necessary before cAK activation may occur.
- 15 Competitive chemical inhibitors are known which can selectively inhibit members of the PDE4 family. There are none known which can effectively select between the different gene products or splice variants of the PDE4 family (Perry and Higgs, 1998). This may be due to the particularly high degree of sequence homology within the proteins of this family around the catalytic site. Without splice-variant selectivity, there are likely to be
- 20 problems with long-term administration of PDE4 inhibitors, such as immunosuppression and metabolic disturbances, possibly with significant CNS effect as well (Teixeira *et al.*, 1997) since PDE4:s are clearly involved in such a wide range of systems at the organismal level. For the family of PDE4 enzymes, the pyrrolidone compound rolipram remains the "gold standard" reference inhibitor. However, its profile of serious side
- 25 effects prevented rolipram from becoming a compound of clinical utility. Principal side effects of rolipram are headaches, nausea, emesis and an unacceptable increase in gastric acid secretion (Barnes, 1995). The PDE4 family is likely to consist of more than the 20 or so isoforms already known in humans (Houslay, Sullivan and Milligan, 1998). Although a potent inhibitor of all known isoforms of PDE4s, the kinetics of inhibition are
- 30 complex and sensitivity varies significantly from isoform to isoform, and even for individual isoforms in different cell backgrounds or cellular compartments (Bolger *et al.*, 1996; Huston *et al.*, 1996; Jacobitz *et al.*, 1996; McPhee *et al.*, 1995; Owens *et al.*, 1997; Wilson *et al.*, 1994). The side effects of rolipram clearly indicate the potential problems associated with general PDE4 inhibition, while different isoform sensitivities, and
- 35 changing sensitivities in different cellular contexts, highlights the potential functional

diversity of the many PDE4 isoforms known, and therefore the therapeutic potential that lies in selective inhibition of individual isoforms.

So far only two PDE5 genes are known and two enzyme variants have been reported. In parallel with other PDE isoforms more splicing variants are to be expected from each gene. The enzyme is a homodimer, each subunit being 93 kDa. The structural organisation of the dimer is very similar to that of the cGKs. PDE5s exist in two distinct forms: one membrane-bound (mPDE5) and one cytosolic (cPDE5) (Pyne *et al.*, 1996). The mPDE5 is activated by PKA and is inhibited by a G-protein dependent mechanism. It is assumed that cPDE5 is part of a "signalling cassette" with NO-regulated guanylate cyclase and PDE3. The latter construction will lead to very short-lived messages whereas the former allows for generation of prolonged cGMP signals

Targeting or anchoring of PDE5s is likely to have its greatest effect through compartmentalisation of cGMP signalling within cells. Associated with the PDE5s will be specific GCs together with specific isoforms of the effector cGK, or cGMP-operated ion channels. cGKs may be attached to specific G-kinase anchoring proteins. Specific subcellular distributions of these components will allow for spatial and temporal gradients of cGMP to be established within cellular compartments. Targeted PDE5 species might serve to control threshold levels of cGMP in the environs of specific cGK molecules, perhaps protecting certain protein complexes from cGK-mediated phosphorylation or manipulating the activity levels of GCs that are necessary before cGK activation may occur.

Competitive chemical inhibitors are known which can selectively inhibit PDE5s. Relatively few isoforms of PDE5 are known to date. PDE5 is found rather specifically in vascular and airway smooth muscle. That sildenafil, with its 5 nM  $IC_{50}$  for PDE5, affects only a subset of vascular smooth muscle is puzzling, but strongly suggests that either multiple PDE5 isoforms or states exist in different vascular smooth muscle, presumably with different sensitivities to sildenafil, or more likely, other cGMP-hydrolysing PDEs are important in different vascular smooth muscles.

As to other potentially important cGMP-hydrolysing PDE targets, many are doubtless yet to be discovered. PDE9:s have only been known since the end of 1997, PDE10:s since late 1998. PDE9:s have a rather general distribution (kidney, brain, lung), have a very high affinity for cGMP (about 70 nM) and are inhibitable by the PDE1/5 inhibitor SCH51866 (1.55  $\mu$ M), but "not by sildenafil" (7  $\mu$ M, Soderling *et al.*, 1998). Their

physiological roles and regulation have not been defined (Soderling *et al.*, 1998; Fisher *et al.*, 1998), but the best suggestions are that they may be involved in keeping cGMP at very low levels when activated, and may, in kidney, be involved in termination of ANP signalling, and therefore inhibition may help potentiate natriuresis without causing deleterious drops in blood pressure (Soderling *et al.*, 1998).

It is clear that PDEs possess heterogeneity, particularly in their amino terminal, or "regulatory" regions, and the approach outlined in this application exploits those differences between isoforms and splice variants to produce what should be confined and defined therapeutic effects. Furthermore, in many cases it may be expected that dislocation of an active enzyme from a targeted site of action will have little effect on average cellular concentrations of their preferred cyclic nucleotide substrate, although significant increases may occur at the now PDE-free site of action. This may have significance where an acute short-term process is the therapeutic target, but an integrative gene-regulation effect may occur upon general, non-specific PDE inhibition and overall cyclic nucleotide increase in the cell.

### Detailed disclosure

In the present specification and claims, the term "influence" covers any influence to which the cellular response comprises a redistribution. Thus, e.g., heating, cooling, high pressure, low pressure, humidifying, or drying are influences on the cellular response on which the resulting redistribution can be quantified, but perhaps the most important influence is the influence of contacting or incubating the cell or cells with a substance which is known or suspected to cause a redistribution or modify a change of redistribution. In another embodiment of the invention the influence could be substances from a compound drug library.

In the present context, the term "green fluorescent protein" (GFP) is intended to indicate a protein which, when expressed by a cell, emits fluorescence upon exposure to light of the correct excitation wavelength (cf. Chalfie, M. *et al.* (1994) Science 263, 802-805). In the following, GFP in which one or more amino acids have been substituted, inserted or deleted is also termed "modified GFP". "GFP" as used herein includes wild-type GFP derived from the jelly fish *Aequorea victoria* and modifications of GFP, such as the blue fluorescent variant of GFP disclosed by Heim *et al.* (Heim, R. *et al.* (1994).

- Proc.Natl.Acad.Sci. 91:26, pp 12501-12504), and other modifications that change the spectral properties of the GFP fluorescence, or modifications that exhibit increased fluorescence when expressed in cells at a temperature above about 30°C described in PCT/DK96/00051, published as WO 97/11094 on 27 March 1997 and hereby
- 5 incorporated by reference, and which comprises a fluorescent protein derived from *Aequorea* Green Fluorescent Protein or any functional analogue thereof, wherein the amino acid in position 1 upstream from the chromophore has been mutated to provide an increase of fluorescence intensity when the fluorescent protein of the invention is expressed in cells. Preferred GFP variants are F64L-GFP, F64L-Y66H-GFP and F64L-S65T-GFP. An
- 10 especially preferred variant of GFP for use in all the aspects of this invention is EGFP (DNA encoding EGFP which is a F64L-S65T variant with codons optimized for expression in mammalian cells is available from Clontech, Palo Alto, plasmids containing the EGFP DNA sequence, cf. GenBank Acc. Nos. U55762, U55763).
- 15 The terms "intracellular signalling pathway" and "signal transduction pathway" are intended to indicate the coordinated intracellular processes whereby a living cell transduces an external or internal signal into cellular responses. Said signal transduction will involve an enzymatic reaction said enzymes include but are not limited to protein kinases, GTPases, ATPases, protein phosphatases, phospholipases and cyclic
- 20 nucleotide phosphodiesterases. The cellular responses include but are not limited to gene transcription, secretion, proliferation, mechanical activity, metabolic activity, cell death.

- The term "second messenger" is used to indicate a low molecular weight component
- 25 involved in the early events of intracellular signal transduction pathways.

- The term "luminophore" is used to indicate a chemical substance which has the property of emitting light either inherently or upon stimulation with chemical or physical means. This includes but is not limited to fluorescence, bioluminescence, phosphorescence,
- 30 chemiluminescence.

The term "mechanically intact living cell" is used to indicate a cell which is considered living according to standard criteria for that particular type of cell such as maintenance of normal membrane potential, energy metabolism, proliferative capability, and has not

experienced any physically invasive treatment designed to introduce external substances into the cell such as microinjection.

In the present context, the term "permeabilised living cell" is used to indicate cells where  
5 a pore forming agent such as Streptolysin O or *Staphylococcus Aureus*  $\alpha$ -toxin has been applied and thereby incorporated into the plasma membrane in the cells. This creates proteinaceous pores with a defined pore size in the plasma membranes of the exposed cells. Pores could also be made by electroporation, i.e. exposing the cells to high voltage discharges, a procedure that creates small holes in the plasma membrane by  
10 coagulating integral membrane proteins. Treatment with a mild detergent such as saponin may accomplish the same thing. Common to all these treatments is that pores are formed only in the plasma membrane without affecting the integrity of cytoplasmic structural elements and organelles. The term living in this context means that the permeabilised cell or cells bathed in a solution mimicking the intracellular milieu still have  
15 functional organelles, such as actively respiring mitochondria and endoplasmatic reticulum that can take up and release calcium ions, and functional structural elements. In one embodiment this method is applied so that substances that normally can not traverse the plasma membrane, but most likely exert their influence intracellularly, can be introduced and their influence studied. In another embodiment this method is used to  
20 record the response to an influence from many cells simultaneously.

In the present context, the term "permeabilisation" is intended to indicate the selective disruption of the plasma membrane barrier so that soluble substances freely mobile in the cytosol may be lost from the interior of the cells. The permeabilisation can be  
25 achieved as described above under "permeabilised living cells" or by using other chemical detergents such as Triton X-100 or digitonin in carefully titrated amounts.

The term "physiologically relevant", when applied to an experimentally determined redistribution of an intracellular component, as measured by a change in the  
30 luminescence properties or distribution, is used to indicate that said redistribution can be explained in terms of the underlying biological phenomenon which gives rise to the redistribution.

The terms "image processing" and "image analysis" are used to describe a large family  
35 of digital data analysis techniques or combination of such techniques which reduce

ordered arrays of numbers (images) to quantitative information describing those ordered arrays of numbers. When said ordered arrays of numbers represent measured values from a physical process, the quantitative information derived is therefore a measure of the physical process.

5

The term "mammalian cell" is intended to indicate any living cell of mammalian origin. The cell may be an established cell line, many of which are available from The American Type Culture Collection (ATCC, Virginia, USA) or a primary cell with a limited life span derived from a mammalian tissue, including tissues derived from a transgenic animal, or

10 a newly established immortal cell line derived from a mammalian tissue including transgenic tissues, or a hybrid cell or cell line derived by fusing different celltypes of mammalian origin e.g. hybridoma cell lines. The cells may optionally express one or more non-native gene products, e.g. receptors, enzymes, enzyme substrates, prior to or in addition to the fluorescent probe. Preferred cell lines include but are not limited to

15 those of fibroblast origin, e.g. BHK, CHO, BALB, or of endothelial origin, e.g. HUVEC, BAE (bovine artery endothelial), CPAE (cow pulmonary artery endothelial), HLMVEC (human lung microvascular endothelial cells), or of airway epithelial origin, e.g. BEAS-2B, or of pancreatic origin, e.g. RIN, INS-1, MIN6, bTC3, aTC6, bTC6, HIT, or of hematopoietic origin, e.g. primary isolated human monocytes, macrophages, neutrophils,

20 basophils, eosinophils and lymphocyte populations, AML-14, AML-193, HL-60, RBL-1, U937, RAW, JAWS, or of adipocyte origin, e.g. 3T3-L1, human pre-adipocytes, or of neuroendocrine origin, e.g. AtT20, PC12, GH3, muscle origin, e.g. SKMC, A10, C2C12, renal origin, e.g. HEK 293, LLC-PK1, or of neuronal origin, e.g. SK-N-DZ, SK-N-BE(2), HCN-1A, NT2/D1.

25

The term "hybrid polypeptide" is intended to indicate a polypeptide which is a fusion of at least a portion of each of two proteins, in this case at least a portion of the green fluorescent protein, and at least a portion of a catalytic and/or regulatory domain of a protein kinase. Furthermore a hybrid polypeptide is intended to indicate a fusion

30 polypeptide comprising a GFP or at least a portion of the green fluorescent protein that contains a functional fluorophore, and at least a portion of a biologically active polypeptide as defined herein provided that said fusion is not the Glucocorticoid Receptor-GFP disclosed by Carey, KL et al. and Guiliano, KA et al., respectively. Thus, GFP may be N- or C-terminally tagged to a biologically active polypeptide, optionally via

35 a linker portion or linker peptide consisting of a sequence of one or more amino acids.

The hybrid polypeptide or fusion polypeptide may act as a fluorescent probe in mechanically intact or permeabilised living cells carrying a DNA sequence encoding the hybrid polypeptide under conditions permitting expression of said hybrid polypeptide.

- The term hybrid polypeptide or fusion polypeptide is intended also to include the term
- 5 "fluorescent probe", where the latter is used to indicate a fluorescent fusion polypeptide comprising a GFP or any functional part thereof which is N- or C-terminally fused to a biologically active polypeptide as defined herein, optionally via a peptide linker consisting of one or more amino acid residues, where the size of the linker peptide in itself is not critical as long as the desired functionality of the fluorescent probe is maintained. A
- 10 fluorescent probe according to the invention is expressed in a cell and basically mimics the physiological behaviour of the biologically active polypeptide moiety of the fusion polypeptide.

- The term "kinase" is intended to indicate an enzyme that is capable of phosphorylating a
- 15 cellular component.

The term "protein kinase" is intended to indicate an enzyme that is capable of phosphorylating serine and/or threonine and/or tyrosine in peptides and/or proteins.

- 20 The term "phosphatase" is intended to indicate an enzyme that is capable of dephosphorylating phosphoserine and/or phosphothreonine and/or phosphotyrosine in peptides and/or proteins.

- The term "cyclic nucleotide phosphodiesterase" is intended to indicate an enzyme that is
- 25 capable of inactivating the second messengers cAMP and cGMP by hydrolysis of their 3'-ester bond.

- In the present context, the term "biologically active polypeptide" is intended to indicate a polypeptide affecting intracellular processes upon activation, such as an enzyme which
- 30 is active in intracellular processes or a portion thereof comprising a desired amino acid sequence which has a biological function or exerts a biological effect in a cellular system. In the polypeptide one or several amino acids may have been deleted, inserted and/or replaced to alter its biological function, e.g. by rendering a catalytic site inactive or by disrupting the targeting sequence. In another embodiment, one or several amino acids
- 35 may have been deleted, inserted and/or replaced without altering the biological function

of the polypeptide, that is, it remains biologically equivalent. Preferably, the biologically active polypeptide is selected from the group consisting of proteins taking part in an intracellular signalling pathway, such as enzymes involved in the intracellular phosphorylation and dephosphorylation processes including kinases, protein kinases  
5 and phosphorylases as defined herein, but also proteins making up the cytoskeleton play important roles in intracellular signal transduction and are therefore included in the meaning of "biologically active polypeptide" herein. More preferably, the biologically active polypeptide is a protein which according to its state as activated or non-activated changes localisation within the cell, preferably as an intermediary component in a signal  
10 transduction pathway. Included in this preferred group of biologically active polypeptides are cAMP dependent protein kinases, 'inhibitor of NF-kappaB' kinases, and cyclic nucleotide phosphodiesterases.

The term "a substance" is intended to indicate any sample which has a biological  
15 function or exerts a biological effect in a cellular system. The sample may be a sample of a biological material such as a sample of a body fluid including blood, plasma, saliva, milk, urine, or a microbial or plant extract, an environmental sample containing pollutants including heavy metals or toxins, or it may be a sample containing a compound or mixture of compounds prepared by organic synthesis or genetic techniques.

20

The phrase "any change in fluorescence" means any change in absorption properties, such as wavelength and intensity, or any change in spectral properties of the emitted light, such as a change of wavelength, fluorescence lifetime, intensity or polarisation, or any change in the intracellular localisation of the fluorophore. It may thus be localised to  
25 a specific cellular component (e.g. organelle, membrane, cytoskeleton, molecular structure) or it may be evenly distributed throughout the cell or parts of the cell.

The term "organism" as used herein indicates any unicellular or multicellular organism preferably originating from the animal kingdom including protozoans, but also organisms  
30 that are members of the plant kingdoms, such as algae, fungi, bryophytes, and vascular plants are included in this definition.

The term "nucleic acid" is intended to indicate any type of poly- or oligonucleic acid sequence, such as a DNA sequence, a cDNA sequence, or an RNA sequence.

The term "biologically equivalent" as it relates to proteins is intended to mean that a first protein is equivalent to a second protein if the cellular functions of the two proteins may substitute for each other, e.g. if the two proteins are closely related isoforms encoded by different genes, if they are splicing variants, or allelic variants derived from the same gene, if they perform identical cellular functions in different cell types, or in different species. The term "biologically equivalent" as it relates to DNA is intended to mean that a first DNA sequence encoding a polypeptide is equivalent to a second DNA sequence encoding a polypeptide if the functional proteins encoded by the two genes are biologically equivalent.

10

The term "fixed cells" is used to mean cells treated with a cytological fixative such as glutaraldehyde or formaldehyde, treatments which serve to chemically cross-link and stabilize soluble and insoluble proteins within the structure of the cell. Once in this state, such proteins cannot be lost from the structure of the now-dead cell.

15

In the present context a "quantitative fluorescence redistribution assay" is intended to indicate an assay whereby it is possible to observe and quantify the subcellular localisation and possible redistribution of an biologically active polypeptide, or part thereof, genetically or chemically tagged with a luminophore inside an intact living cell or cells or permeabilised living cells. The subcellular location and redistribution may be monitored using fluorescence microscopy or fluorescence imaging microscopy but is preferably monitored using a fluorescence imaging plate reader or a fluorescence plate reader for improved throughput. A more thorough description is given in Appendix A.

25 In the present context a "mortal cell line" is used to indicate animal cells that may grow in vitro, given the right conditions, but that have a definite life span of a number of cell divisions or days, week or months beyond which it is not at present possible to keep them alive.

30 In the present context an "immortalised cell line" is used to indicate cells of animal origin where the normal limitations for cell life and number of cell divisions do not apply. Essentially, such cells can live, grow and divide for an unlimited or very long (years to decades) time.

The term "targeting sequence" is used to indicate the amino-acid sequence of a biologically active polypeptide that contains the actual structure or structures necessary for association of the biologically active polypeptide with its native intracellular binding sites. The term "targeting sequence" is also used to indicate the amino-acid sequence of  
5 a protein that contains the actual structure or structures necessary for association of a biologically active polypeptide with the protein.

The term "targeting" is used to indicate the process whereby a spatially distributed protein is directed to the intracellular sites and maintained at the intracellular sites to  
10 which it is normally anchored or associated. These anchoring sites are normally assumed to be the intracellular sites where the protein has its optimal function for the cell.

The term "dislocate" and derivatives thereof is used to indicate the process whereby an intracellularly spatially distributed protein is forced to detach from its normal anchoring or  
15 association structures in the cells due to intercalation of another, preferably smaller, compound at the site of anchoring or association. This usually means that the optimal function of the protein within the cell is lost or reduced and that a larger portion of the protein molecules are freely mobile within the cytoplasm.

20

In the present context a "screening assay" is intended to mean any measurement protocol, including materials, cells, instruments, chemicals, reagents, detection units, calibration and quantification procedures used to measure a response from mechanically intact or permeabilised living cells relevant to influences on an intracellular pathway.

25

In the present context a "primary screening assay" is used to indicate the first screening assay in a discovery project that is used to select and sort all compounds available to the project according to the quantified effect of the compounds in the assay.

30 In the present context a "counterscreen" is intended to mean a screening assay that is relevant to a phenomenon that is undesirable seen from the point of view of the discovery project.

In the present context a "discovery project" is intended to mean the process whereby  
35 general or specific ideas about ways of how to modulate an intracellular signalling

- pathway are exploited in order to find new chemical compounds that can be used to modulate the intracellular signalling pathway and thereby treat, reduce or abolish symptoms associated with a condition or a disease that is lethal, degenerative, performance-reducing or just uncomfortable to an animal, preferably a human being. The
- 5 aim of the discovery project is to produce drug candidates that can be tested as potential drugs in an animal, preferably in human beings. The term "discovery project" also encompasses the actual group of individuals, screening assays, tests, machinery, cells, animals and compounds involved in different aspects of the project.
- 10 The term "tagging" is used to indicate the process whereby a luminophore is genetically or chemically attached to the protein, or part of the protein, of interest to the discovery project.

- The term "primary hit" is used to indicate compounds identified in the primary screening
- 15 assay as having at least the minimum level of desired effect that has been specified in the discovery project.

- The term "primary lead compound" is used to indicate a primary hit that has at least the minimal level of desired potency and specificity predetermined by the discovery project.
- 20

- The term "dose-response relationship" is in the present context intended to mean a clear correlation between the quantified response of cells in a screening assay to application of an influence, such as a compound, and the concentration of the applied influence. The response to the influence may be both an up-regulation and a down-regulation of the
- 25 quantitated parameter used in the screening assay.

- In the present context, the term "potency" is intended to mean the ability of an influence to affect the process under study. The process under study may be, for example a screening assay or a specific physiological or pathophysiological response in an animal.
- 30

- In the present context, the term "selectivity" is intended to mean the difference in potency on the desired process, such as a screening assay, and an undesired process, such as a counterscreen, with the view of the discovery project. An influence or a compound is said to display selectivity if the potency for the desired process is higher than for the
- 35 undesired process.

In the present context, the term "structure-activity relationship" or "SAR" is intended to mean the situation where a direct relationship exists between a compound and modifications made to the compound and the activity of the compound and the  
5 modifications made to the compound in one or more screening assays. The process of building a SAR may be used to direct the chemical construction of new compounds with higher potency and selectivity than the original compound.

The term "drug candidate lead" is used to indicate compounds that may be pursued by a  
10 discovery project as potential candidates for the final outcome of the project.

In the present context, the term "efficacy" is intended to mean the ability of a compound to affect the process or condition under study. It is closely related to the term "potency" but is in the present context used when relating to effects of a compound on more  
15 complex screening assays than the primary screening assay or counterscreens and when relating to effects of a compound in animals.

In the present context, the term "toxicity" is intended to mean that a compound in some way is toxic to cells, tissues or animals. The toxicity means that the cells, tissues or  
20 animals will in some way be harmed if the compound is applied at a sufficient concentration. The effects may ultimately lead to cell, tissue or animal death or a limited life compared to the normal condition.

In the present context, the term "physiology" is intended to mean the normal function of  
25 biological and biochemical processes inside cells, between cells and in the whole organism or animal.

In the present context, the term "pathophysiology" is intended to mean deviations from the normal function of biological and biochemical processes inside cells, between cells  
30 and in the whole organism or animal that may be part of a condition or disease.

In the present context, the term "pathogenesis" is intended to mean the process, be it genetical, biological, biochemical, chemical or environmental, that ultimately may explain, at least in part, the apparent pathophysiology associated with a condition or  
35 disease in an animal.

In the present context, the term "fractionated cells" is intended to mean the outcome of a simple division of initially mechanically intact living cells into two fractions, particulate (the components that can be sedimented by centrifugation at more than 10 000xg and  
5 not more than 100 000xg for 10 minutes) and soluble fraction (the soluble components and small membrane fragments that do not sediment), after subjecting the cells to plasma membrane disruption either mechanically with some form of homogeniser or sonicator or osmotically (hypoosmotic shock) or through some kind of permeabilisation of the plasma membrane with detergents, toxins or electroporation.

10

The term "parenteral route of administration" is used to indicate the administration of a drug or compound in solution to an animal, such as a mammal or a human, by injection or infusion of the drug or compound into the bloodstream of the animal via an injection needle inserted into one of the animal's blood vessels, preferably a vein.

15

The term "oral route of administration" is used to indicate the administration of a drug or compound in solution or as a solid to an animal, such as a mammal or a human, by placing the drug or compound in the mouth of the animal so that the animal itself can swallow the drug or compound or have it delivered to the stomach or intestine by  
20 intubation. When the drug or compound enters the stomach and intestine it will be taken up over the mucosa into the bloodstream and administered via the blood stream to the tissues and organs where it is to exert its effect, or it will be acting locally in the stomach and intestine.

25 The term "pulmonary route of administration" is used to indicate the administration of a drug or compound as an aerosol with either solid or liquid particles to an animal, such as a mammal or a human, by placing the drug or compound container close to or in contact with the mouth and/or nose of the animal so that the animal itself can inhale the drug or compound aerosol. When the drug or compound enters the peripheral bronchioles and  
30 alveoli it will be taken up over the alveolar membrane, either into the bloodstream and administered via the blood stream to the tissues and organs where it is to exert its effect or it will act locally in the lungs on lung, vessel and muscle cells as well as any other cell type present therein.

The term "cutaneous route of administration" is used to indicate the administration of a drug or compound in solution or as a solid to an animal, such as a mammal or a human, by placing the drug or compound on the skin of the animal. The drug can then enter the blood vessels under the skin as it is permeating the skin and thereby be taken up into the  
5 bloodstream and administered via the blood stream to the tissues and organs where it is to exert its effect. It may also exert an effect locally on the site of application on the skin.

The term "rectal route of administration" is used to indicate the administration of a drug or compound in solution or as a solid to an animal, such as a mammal or a human, by  
10 placing the drug or compound in the rectal cavity of the animal. When the drug or compound enters the rectum and parts of the large intestine it will be taken up over the mucosa into the bloodstream and administered via the blood stream to the tissues and organs where it is to exert its effect, or it will act locally in the rectum and parts of the large intestine.

15 Several IKKs and very many phosphodiesterases (PDE:s) are known. They are grouped in families according to functional criteria. Within each family there may be several members - isoforms- encoded by different genes. Each isoform may give rise to several splice variants. This hierarchy is evidenced at the sequence level: isoforms are more  
20 similar to each other than to members of other families; splice variants are more similar to each other than to other PDE:s. Each specific PDE thus contains sequences that are unique to itself, as well as sequences that are shared between isoforms and/or families. When setting up a program to identify pharmacological agents that affect the intracellular distribution of a target IKK or PDE, it is first necessary to choose the target from the IKKs  
25 and PDE:s known. This may be done according to various criteria. A first criterion is that it is imperative that the target IKK or PDE be present in the tissue or cell type(s) where the pharmacological agent is to exert its effect. A second criterion is that it is desirable that either the target or a specific anchoring/targeting site not be present in tissues or cell types where no pharmacological effects are desired.

30

Establishing the expression patterns of IKKs and PDE:s in relation to tissues and cell types is best done using the methods of detection of mRNA, e.g. Northern analysis, which is a well established procedure. Briefly, mRNA isolated from a given source is probed with a labelled nucleotide, whose sequence is complementary to the mRNA or a  
35 region in a mRNA of interest. The assay allows the investigator to determine the

stringency of the probing, i.e. to correlate the resulting signal(s) with sequence similarities.

As a first step, the nucleotide sequences of IKKs or PDE:s are compiled and inspected to identify regions that are unique to specific IKKs or PDE:s as well as regions that are  
5 shared among several, many, or all IKKs or PDE:s. Nucleotide sequences may be found in a depository of genetic information, e.g. GenBank, which is a well known resource. The inspection of the sequences may be aided by using computer programs that were developed to align several or many sequences, and in so doing highlighting regions of similarity or lack of the same. Many of these are presented and explained in great detail  
10 in e.g. Sequence Data Analysis Guidebook /edited by S.R.Swindell, Methods in Molecular Biology vol. 70 (1997), from Humana Press Inc. Totowa, New Jersey. When sequences have been identified that are unique to an IKK, or a PDE, or respectively shared by several or many IKKs or PDE:s, oligonucleotide probes based on these sequences may be designed and synthesized. The use of such probes to detect  
15 mRNA is well established in the research community, see e.g. Basic DNA and RNA Protocols/edited by A.J.Harwood, Methods in Molecular Biology vol. 58 (1996), from Humana Press Inc. Totowa, New Jersey. E.g. Life Technologies offer to synthesize specified oligonucleotides.

20 In addition to oligonucleotide probes, mRNA extracted from the tissues and cell types of interest is required, preferably in a form ready to use in Northern analysis. Several companies offer such material, e.g. Invitrogen and Clontech. Briefly, they provide RNA extracted from a great many human and non-human tissues or cell types immobilized on membranes, as an array or size-fractionated.

25 In a next step, a detectable label needs to be attached to the oligonucleotide probe(s). The label is traditionally in the form of a radioactive isotope, but may to advantage be a chemiluminescent reagent or a fluorescent agent. See e.g. DNA Probes by Keller and Manak (1993), from Macmillan Publishers. Several companies offer reagents to label nucleotide probes, e.g. Ambion (Austin, Texas) and Molecular Probes (Eugene, Oregon).

30 The actual probing procedure involves contacting the immobilized mRNA (s) with the probe(s), washing away unbound probe(s) and detecting the signal(s) from the probe(s) that bound under the conditions tested, a positive signal indicating that the target(s) of the probe(s) was present in the sample(s) subjected to the test. In its simplest form, the test is "one-to-one", i.e. each sample of mRNA is exposed to each probe. However, it  
35 may be advantageous to exploit the sequence hierarchy of the IKKs or PDE:s, by first

probing arrays of mRNA from multiple sources with family-specific probes, then examining first positives with isotype-specific probes, and then examining the secondary positives in detail with very specific probes. One could also multiplex the probing by adding different distinguishable fluorescent labels to the probes, thus obtaining

5 information from several probes in one experiment.

The outcome of the analysis is information regarding the expression pattern(s) of IKKs and PDE:s.

Based on their expression pattern(s) specific IKKs and/or PDE:s are then selected for further study, and genetic probes are constructed.

10

In general, a genetic probe, i.e. a "GeneX"-GFP fusion or a GFP-"GeneX" fusion, is constructed using PCR with "GeneX"-specific primers followed by a cloning step to fuse "GeneX" in frame with GFP. The fusion may contain a short vector derived sequence between "GeneX" and GFP (e.g. part of a multiple cloning site region in the plasmid)

15 resulting in a peptide linker between "GeneX" and GFP in the resulting fusion protein.

The fusion may be made using polymerase chain reaction techniques, which are common laboratory procedures, see e.g. PCR Protocols/edited by B.A.White, Methods in Molecular Biology vol. 15 (1993), from Humana Press Inc. Totowa, New Jersey.

20 In more detail, the steps involved include:

- Design of gene-specific primers. Inspection of the sequence of the gene allows design of gene-specific primers to be used in a PCR reaction. Typically, the top-strand primer encompasses the ATG start codon of the gene and the following ca. 20 nucleotides, while the bottom-strand primer encompasses the stop codon and the ca. 20

25 preceding nucleotides, if the gene is to be fused behind GFP, i.e. a GFP-"GeneX" fusion. If the gene is to be fused in front of GFP, i.e. a "GeneX"-GFP fusion, a stop codon must be avoided. Optionally, the full length sequence of GeneX may not be used in the fusion, but merely the part which localizes and redistributes like GeneX in response to a signal.

30 In addition to gene-specific sequences, the primers contain at least one recognition sequence for a restriction enzyme, to allow subsequent cloning of the PCR product.

The sites are chosen so that they are unique in the PCR product and compatible with sites in the cloning vector. Furthermore, it may be necessary to include an exact number of nucleotides between the restriction enzyme site and the gene-specific

35 sequence in order to establish the correct reading frame of the fusion gene and/or a

translation initiation consensus sequence. Lastly, the primers always contain a few nucleotides in front of the restriction enzyme site to allow efficient digestion with the enzyme.

- Identifying a source of the gene to be amplified. In order for a PCR reaction to produce a product with gene-specific primers, the gene-sequence must initially be present in the reaction, e.g. in the form of cDNA. The results of the extensive expression analysis performed previously will provide clear information regarding what tissue(s) are useful as source material. cDNA libraries from a great variety of tissues or cell types from various species are commercially available, e.g. from Clontech (Palo Alto), Stratagene (La Jolla) and Invitrogen (San Diego). Many genes are also available in cloned form from The American Type Tissue Collection (Virginia).
- Optimizing the PCR reaction. Several factors are known to influence the efficiency and specificity of a PCR reaction, including the annealing temperature of the primers, the concentration of ions, notably  $Mg^{2+}$  and  $K^+$ , present in the reaction, as well as pH of the reaction. If the result of a PCR reaction is deemed unsatisfactory, it might be because the parameters mentioned above are not optimal. Various annealing temperatures should be tested, e.g. in a PCR machine with a built-in temperature gradient, available from e.g. Stratagene (La Jolla), and/or various buffer compositions should be tried, e.g. the OptiPrime buffer system from Stratagene (La Jolla).
- Cloning the PCR product. The vector into which the amplified gene product will be cloned and fused with GFP will already have been taken into consideration when the primers were designed. When choosing a vector, one should at least consider in which cell types the probe subsequently will be expressed, so that the promoter controlling expression of the probe is compatible with the cells. Most expression vectors also contain one or more selective markers, e.g. conferring resistance to a drug, which is a useful feature when one wants to make stable transfectants. The selective marker should also be compatible with the cells to be used.

The actual cloning of the PCR product should present no difficulty for the person skilled in the art as it typically will be a one-step cloning of a fragment digested with two different restriction enzymes into a vector digested with the same two enzymes. If the cloning proves to be problematic, it may be because the restriction enzymes did not work well with the PCR fragment. In this case one could add longer extensions to the end of the primers to overcome a possible difficulty of digestion close to a fragment end, or one could introduce an intermediate cloning step not based on restriction enzyme digestion.

Several companies offer systems for this approach, e.g. Invitrogen (San Diego) and Clontech (Palo Alto).

Once the gene has been cloned and, in the process, fused with the GFP gene, the resulting product, usually a plasmid, should be carefully checked to make sure it is as  
5 expected. The most exact test would be to obtain the nucleotide sequence of the fusion-gene.

Once a DNA construct for a probe has been generated, its functionality and usefulness may be tested by subjecting it to the following tests:

- 10 - Transfecting it into cells capable of expressing the probe. The fluorescence of the cell is inspected soon after, typically the next day. At this point, two features of cellular fluorescence are noted:
  - The intensity should usually be at least as strong as that of unfused GFP in the cells. If  
it is not, the sequence or quality of the probe-DNA might be faulty, and should be  
15 carefully checked.
  - The sub-cellular localization is an indication of whether the probe is likely to perform well.

If it localizes as expected for the gene in question, e.g. is excluded from the nucleus, it can immediately go on to a functional test. If the probe is not localized soon after the  
20 transfection procedure, it may be because of overexpression at this point in time, as the cell typically will have taken of very many copies of the plasmid, and localization will occur in time, e.g. within a few weeks, as plasmid copy number and expression level decreases. If localization does not occur after prolonged time, it may be because the fusion to GFP has destroyed a localization function, e.g. masked a protein sequence  
25 essential for interaction with its normal cellular anchor-protein. In this case the opposite fusion might work, e.g. if GeneX-GFP does not work, GFP-GeneX might, as two different parts of GeneX will be affected by the proximity to GFP. If this does not work, the proximity of GFP at either end might be a problem, and it could be attempted to increase the distance by incorporating a longer linker between GeneX and GFP in the DNA  
30 construct.

If there is no prior knowledge of localization, and no localization is observed, it may be because the probe should not be localized at this point, because such is the nature of the protein fused to GFP. It should then be subjected to a functional test.

In a functional test, the cells expressing the probe are treated with at least one compound known to perturb, usually by activating, the signalling pathway on which the probe is expected to report by redistributing itself within the cell.

If the redistribution is as expected, e.g. if prior knowledge tell that it should translocate  
5 from location X to location Y, it has passed the first critical test. In this case it can go on to further characterization and quantification of the response.

If it does not perform as expected, it may be because the cell lacks at least one component of the signalling pathway, e.g. a cell surface receptor, or there is species incompatibility, e.g. if the probe is modelled on sequence information of a human  
10 gene product, and the cell is of hamster origin. In both instances one should identify other cell types for the testing process where these potential problems would not apply.

If there is no prior knowledge about the pattern of redistribution, the analysis of the redistribution will have to be done in greater depth to identify what the essential and indicative features are, and when this is clear, it can go on to further characterization and  
15 quantification of the response.

If no feature of redistribution can be identified, the problem might be as mentioned above, and the probe should be retested under more optimal cellular conditions.

Libraries for cloning of cDNA libraries in the present discovery plan are naturally related  
20 to the target tissues of the projects. For ultimately finding lead compounds useful in the treatment of asthma the cloning libraries should preferably be obtained from one or more of the following tissue or cells types: Bronchial smooth muscle, Lung microvascular endothelial cells, eosinophil granulocytes, Th1 or 2 lymphocytes and alveolar macrophages.

25 For ultimately finding lead compounds useful in the treatment of chronic inflammatory diseases the cloning libraries should preferably be obtained from one or more of the following tissue or cell types: Th1 or 2 lymphocytes, T-lymphocytes, B-lymphocytes, Monocytes, Eosinophil granulocytes, Neutrophil granulocytes, Basophil granulocytes, Tissue specific macrophages (such as the liver Kupffer cells and skin Langerhans cells),  
30 microvascular endothelial cells, vascular endothelial cells, antigen presenting cells, joint connective and synovial cells. For ultimately finding lead compounds useful in the treatment of depression the cloning libraries should preferably be obtained from one or more of the various tissue regions of the brain containing noradrenergic neurons. For ultimately finding lead compounds useful in the treatment of jet lag or circadian clock

resetting the cloning libraries should preferably be obtained from one or more of the various tissues of the brain such as the pineal gland, hypothalamus and substantia nigra. For ultimately finding lead compounds useful in the treatment of hyper- and hypotension and erectile dysfunction the cloning libraries should preferably be obtained from one or  
5 more of the following tissue or cell types: vascular smooth muscle, vascular smooth muscle from resistance vessels on the arterial side of the vascular system, vascular smooth muscle from capacitance vessels on the venous side of the vascular system, vascular smooth muscle cells from small arteries, arterioles, venules or veins, smooth vascular cells lines such as T/G HA-VSMCA10 and A7r5.

10

The cells should always be of animal origin, most likely of mammalian origin and preferably of human origin. The cells could be derived from normal tissue or from tissue of an individual animal having a disease or condition of interest for the project. The cells may also be a mortal or immortalised cell line where the initial cell clone has been  
15 derived from a tissue or cell type as described above. Depending on the discovery project the cells of interest for screening assays will vary but may be chosen from the above mentioned categories.

Once a genetic construct containing the protein of interest and the luminophore, from  
20 here on referred to as "the original fluorescent probe", has been transfected into a relevant cell type, as described above under 'preferred cell types for cloning libraries' the cells are monitored for the appearance of spatially distributed or randomly distributed intracellular fluorescence. Based on prior knowledge regarding the distribution of the actual protein different patterns can be expected. If for example previous studies have  
25 found the protein associated only with the particulate fraction of fractionated cells, it can be expected to find a spatial distribution of the original fluorescent probe to the plasma membrane, internal membrane/organelle structures or structural cytoplasmic elements such as microtubules and microfilaments. If on the other hand previous studies report that the protein has been found mostly in the soluble fraction of fractionated cells one  
30 can expect to find a homogenous or nonhomogenous distribution of the original fluorescent probe throughout the cytoplasm and perhaps also in the nucleus. For proteins where previous studies have found a mixed localisation to both the particulate and soluble fraction of fractionated cells any mixture in the two distribution patterns mentioned above for the original fluorescent probe can be expected. For proteins where  
35 no prior knowledge is at hand a simple cell fractionation and Western Blotting can be

made, one can use immunohistochemistry of fixed cells of relevance or one can decide to rely on the distribution observed for the original fluorescent probe. At this stage of the project, a normal distribution pattern of the original fluorescent probe may be established after such studies as outlined above. The effects of physiologically important and

- 5 relevant cellular activation on the distributed pattern of the original fluorescent probe is also established. It will also become evident if the pattern of distribution changes, i.e. if a redistribution of the original fluorescent probe occurs as a consequence of applying a physiologically important and relevant influence.

- 10 The strategy described herein is used to search for chemical entities which can interfere with the protein-protein interactions that occur amongst biologically active polypeptides and their anchoring/regulating partners, and thereby interfere with the effectiveness of a biologically active polypeptide's action within its cellular environment. The strategy will
- 15 have different effects, and require slightly different discovery methods depending on the nature of the interaction. The possibilities are as follows:

- 1) A biologically active polypeptide is permanently located at its targeting point, and either remains permanently active there, or its activity is modulated in some way by post-  
20 translational modification such as phosphorylation or by binding of modulators to non-catalytic regulatory sites. Dislocation from the targeting site will remove the biologically active polypeptide from a localised site of action, and may also lead to inactivation of its inherent catalytic activity.
- 2) A biologically active polypeptide is permanently located at its targeting point, and  
25 remains inactive there until its activity is modulated in some way by post-translational modification, such as phosphorylation or by binding of modulators to non-catalytic regulatory sites. Dislocation from the targeting site will remove the biologically active polypeptide from a localised site of action, and may also lead to activation of its inherent catalytic activity, albeit away from its original anchoring site.
- 3) A biologically active polypeptide is inactive in its unattached or untargeted form,  
30 and when activated (as described in "1" above), or partially activated, it redistributes within the cell and becomes attached to its targeting site, its activity being restricted to the anchoring site and possibly enhanced by interaction with the anchoring protein or some associated factor, or at some later time inhibited by the anchoring protein or an  
35 associated regulatory factor. Any agent which prevents association of the biologically active polypeptide with its anchoring or targeting site will prevent it from locating to the

preferred site of action, and may also prevent the biologically active polypeptide from becoming fully activated by the appropriate stimulus whilst in the untargeted state.

- 4) A biologically active polypeptide is active in its unattached or untargeted form, and when inactivated (as described in "1" above), or partially inactivated, it redistributes within the cell and becomes attached to its targeting site, whereby its activity is inhibited by interaction with the anchoring protein or an associated regulatory factor. Subsequent stimuli may then activate and release the biologically active polypeptide. Any agent which prevents association of the biologically active polypeptide with its anchoring or targeting site will prevent it from relocating to the anchoring position, and may also prevent the biologically active polypeptide from ever being inactivated. In addition, if the biologically active polypeptide cannot target to its anchoring site, it may not be possible subsequently to activate the biologically active polypeptide in the appropriate way in the untargeted state.

- 15 When a specific subcellular distribution of a GFP-based IKK or PDE probe has been identified, it may be advantageous to narrow down which part of the IKK or PDE is responsible for this effect. The advantage is twofold: It may suggest the design of peptide leads, and it may eventually aid in defining the binding partner. Knowledge of both partners involved in specific binding may aid in the selection of compound libraries to screen for inhibition of the specific binding.

- To identify the region of the IKK or PDE involved in specific binding, one may make GFP-based fusions with progressively shorter parts of the IKK or PDE, and examine the cellular distribution of these constructs. If there is prior knowledge of functional domains, one may start with the domain believed to confer specific binding to a subcellular structure. The generation of constructs to test may consist of selecting a particular part of the IKK or PDE to fuse to GFP, or it may involve the generation of in-frame deletions in the IKK or PDE part of the fusion. Both approaches have been widely used in molecular genetic studies.

- 30 When a region has been identified that appears responsible for conferring a specific subcellular distribution upon an IKK or a PDE, the amino acid residues most important for this trait may be identified by a more detailed analysis, e.g. substituting them one by one with e.g. an alanine residue, a so called Ala-scan, which also has been used extensively in molecular genetic studies.
- 35 To identify the identity of the cellular protein partaking in the specific distribution of the IKK or PDE, one may exploit the knowledge about the region of the IKK or PDE

responsible for the subcellular distribution; for example, one may use the region of the IKK or PDE as bait in a genetic two hybrid screen to pull out its binding partner. Several companies offer two hybrid systems, e.g. Life Technologies.

- 5 The knowledge about the normal distribution of the original fluorescent probe is used to establish which part or which parts of the terminal (or entire) amino-acid sequence that is important for the attachment of this fluorescent probe to subcellular structures, giving it its specific spatially distributed pattern in the cell or cells, when such a pattern has been established as the normal distribution of this fluorescent probe. This may be
- 10 accomplished by creating new fluorescent probes where a systematic deletion of short N- or C-terminal or internal sequences (number of DNA bases) of the original fluorescent probe are made. These new shorter variants of the of the original fluorescent probe construct are transfected into the cells of interest and then the cells are examined for spatial distribution of the new fluorescent probes as described above for the original
- 15 fluorescent probe. In those cells where the new fluorescent probe distribution pattern is different from the original fluorescent probe distribution pattern it is evident that part of the, or the entire, targeting sequence has been deleted. The DNA- or amino-acid sequence of the missing part therefore contains the structural information necessary for association of the original fluorescent probe with its intracellular binding sites.

20

- Peptides for inhibition of the established normal distribution of the original fluorescent probe are designed according to the hypothesis, that the deduced targeting sequence, or sequences, in the original fluorescent probe amino-acid sequence are the important sequences for the actual spatial distribution of the original fluorescent probe in intact
- 25 living cells, is tested. This is done by producing peptides of identical amino-acid sequence as the deduced targeting sequence or parts thereof and introducing them into the cytoplasm, either by microinjection or transient or permanent permeabilisation, of cells containing the original fluorescent probe and thereafter monitoring the spatial distribution of the original fluorescent probe in the cells. If the deduced targeting
- 30 sequence or sequences are of importance for the actual spatial distribution of the original fluorescent probe in intact living cells, the introduced peptides will self-associate with the anchoring sites for the original fluorescent probe and thereby disrupt the normal distribution of the original fluorescent probe. In order to have this effect, the introduction of the peptides should change the original distribution pattern so that a decrease in
- 35 fluorescence of 10% or more, compared to the pattern before their introduction, can be

detected. This is done by observing the same cells before and after administration of the peptides. When peptides that fulfil this criterion have been found they are called 'peptide leads' and will hereafter be referred to using this expression. These peptide leads can now be used as a basis for the design of organic molecules that can be used eventually  
5 to disrupt the spatial distribution of the original fluorescent probe but also as control compounds in screening assays.

PS473 and derivatives thereof show a discrete intracellular localisation that allow establishment of assay systems valuable in the screening for compounds that modulate  
10 targeting of said probes. IKK $\beta$  interacts with multiple components of the I $\kappa$ B complex. Construction of the described assay systems has allowed us to screen for compounds that interact with specific or multiple targeting sites. This approach allow for development of compounds that through modulation of one (or several) of multiple targeting sites of IKK $\beta$  (or other IKKs) will provoke either a partial or a complete inhibition  
15 of the NF- $\kappa$ B activation. In addition cell specific anchoring will allow design of compounds that only affect defined cell types.

In parallel to the above mentioned step wherein peptide leads are defined, the distribution pattern found for the original fluorescent probe is compared to the naturally  
20 occurring spatial distribution of the protein on which the original fluorescent probe is based. This may be accomplished by observing fixed primary cells separated from or still within the tissue of interest and fixed cells that contain the original fluorescent probe. Thereafter the protein is stained using ordinary immunocytochemical or immunohistochemical methods and the spatial distribution revealed by this staining  
25 procedure is compared to the spatial distribution of the original fluorescent probe. It is desirable, but not required, that a high degree of correlation between the two patterns obtained in this step can be observed.

Establishment of a primary screening assay is normally done by making use of the cells  
30 of interest containing the original fluorescent probe as the basis for a screening assay. Depending on the knowledge acquired about the behaviour of the original fluorescent probe when subjecting the cells to physiologically relevant influences the assay procedure can be chosen: 1. If the fluorescent probe normally is targeted to specific sites and stays associated with these sites during stimulation of the intracellular pathway, the  
35 assay should preferably be designed to detect dislocation of the original fluorescent

- probe from the targeting sites in mechanically intact or permeabilised living cells. This is an assay where the dislocation can be detected within minutes after application of an influence and the time frame for the detection and time for exposing the cells to an influence should be chosen to match this. 2. If the desire is to disrupt the actual targeting event rather than dislocate already targeted fluorescent probe the influence may need 5 hours to produce a detectable response. The actual measurement, still of a change in the fluorescence or luminescence distribution pattern compared to the normal distribution pattern for the original fluorescent probe, may be made at two time points; before and after the influence has exerted any effect it may have. This is an assay where the effect 10 of an influence may require several hours to produce a detectable response and the time frame for the detection and time for exposing the cells to an influence should be chosen to match this. 3. If the fluorescent probe normally redistributes between two intracellular sites upon activation of the intracellular pathway one may either want to disrupt the initial targeting or dislocate the original fluorescent probe from its initial or resting anchoring 15 site. In this case procedure no. 1 above may be used. If the desire instead is to inhibit the association of the original fluorescent probe with the site it redistributes to during activation of the intracellular pathway the targeting sequence of this site should be in focus for the lead peptide generation. This is an assay where the redistribution may be detected within minutes after application of an influence and the time frame for the 20 detection and time for exposing the cells to an influence should be chosen to match this. Furthermore, any influence applied to inhibit the targeting of the original fluorescent probe upon its redistribution may need to be added to the cells before activation of the intracellular pathway.
- 25 While the original fluorescent probe and peptide leads will be used in the actual primary screening assay, it is also desirable to have a counterscreen or counterscreens directed at protein isoforms that one does not wish to affect. In order to accomplish this, constructs are made for new fluorescent probes encoding the protein isoforms tagged with GFP. These constructs are subsequently transfected into the cells of interest. When 30 the new fluorescent probes are expressed in the cells, some of the cells are chosen as the basis for new cell lines that can be used in the counterscreen or counterscreens.

Suitable probes for this purpose comprise DNA constructs encoding fusion polypeptides comprising forms of IKK $\alpha$ , IKK $\beta$ , IKK $\gamma$  or NIK and GFP; PDE1, PDE2, PDE3, PDE4, 35 PDE5, PDE6, PDE7, PDE8, PDE9 or PDE10 and GFP; PKA catalytic subunit and GFP.

In a preferred embodiment the DNA constructs will encode fusion polypeptides comprising isoforms of IKK $\beta$ , PDE 4, mPDE5, PKA catalytic subunit and GFP.

- 5 In a much preferred embodiment the DNA construct is selected from table 1.

**Table 1** list of the fusion constructs of the invention by the names used herein as well as by reference to relevant SEQ ID NOs of sequences of DNA encoding the construct and full amino acid sequences

Fusion construct	DNA sequence SEQ ID NO:	Protein Sequence SEQ ID NO:
PDE 4D3 - EGFP	1	2
PDE 4D4 - EGFP	3	4
PDE 4D5 - EGFP	5	6
PDE 5 - EGFP	7	8
IKK $\beta$ - EGFP	9	10
NF-KappaB - EGFP	11	12
EGFP - IKK $\beta$	13	14
EGFP - IKK $\beta$ L2	15	16

10

The cell lines established for the primary screen and the counterscreen, or counterscreens, are used to establish peptide leads that more specifically dislocate the desired isoform of the protein of interest compared to other isoforms of the same protein.

- The peptide leads are introduced into the cells as described above and the changes in
- 15 spatial distribution of the original and counterscreen fluorescent probes are quantified and dose-response relationships are established for each lead peptide. Thereafter the dose-response relationships are compared. A peptide lead is considered specific for the original fluorescent probe if the dose of the peptide required to dislocate at least 10% of the fluorescent probes in the counterscreen or counterscreens are at least two times
- 20 higher than the dose required to dislocate 10% of the original fluorescent probe. The lead peptides with the biggest dose difference when comparing the primary and the counterscreen dose-response relationships are chosen as the basis for the next step in the discovery project.

- In one embodiment the primary screening assay and counterscreen or counterscreens
- 25 are used to define specificity of the peptide leads by using a procedure that compares their ability to cause a dislocation, disruption of targeting or inhibition of redistribution of the original fluorescent probe in the primary screening assay to their ability to cause a

dislocation, disruption of targeting or inhibition of redistribution of the new fluorescent probes in the counterscreen or counterscreens.

In a preferred embodiment the dose of a peptide lead required to cause a quantified  
5 dislocation, disruption of targeting or inhibition of redistribution of the original fluorescent probe of at least 10% in the primary screening assay is 50% or less of the dose required to cause a quantified dislocation, disruption of targeting or inhibition of redistribution of the new fluorescent probes of at least 10% in the counterscreen or counterscreens.

The invention provides for a specificity index which may be constructed describing a  
10 numerical relationship, with the primary screening assay result first, of the dose required to produce half-maximal effect in the primary assay compared to the dose required to produce half-maximal effect in the counterscreen or counterscreens.

In one embodiment the peptide leads chosen for further use in the discovery project have a specificity index of 1 to 2.

15 In another embodiment the peptide leads chosen for further use in the discovery project have a specificity index between 1 to 2 and 1 to 10.

In a further embodiment the peptide leads chosen for further use in the discovery project have a specificity index between 1 to 11 and 1 to 100.

In yet a further preferred embodiment the peptide leads chosen for further use in the  
20 discovery project have a specificity index better than 1 to 100.

Lead peptides are used to create and select libraries of small organic molecules that can be useful in screening assays to find bioactive substances useful as drugs to treat the condition or disease of interest for the project. In this step the amino-acid sequence  
25 information and other structural information about the lead peptide or peptides is used to extract information useful for finding and/or defining and synthesising bioactive organic molecules that can mimic the effect of the lead peptides on the normal spatial distribution pattern of the original fluorescent probe. Such compounds may be useful as drugs to treat the condition or disease of interest for the project. Peptide leads selected by the  
30 discovery project are used to design and assemble compound libraries based on the structural and chemical information inherent in the lead peptides using prior chemical knowledge and computational chemistry approaches so that the compounds have a structure that give them the ability to interact with or bind to the targeting sequence of IKK $\beta$ , PDE 4D X or mPDE5 thereafter testing the compound libraries at a concentration  
35 of 10 or 100 micromolar of each compound in the primary screening assay.

- When the libraries of compounds have been defined and are at hand it is time to initiate primary screening. In this procedure, cells containing the original fluorescent probe are contacted with the compounds. The compounds are all tested at just one or a few
- 5 concentrations, typically 10 and 100 micromolar, in a highly parallel fashion using a quantitative fluorescence redistribution assay. Compounds that cause a change in the quantitated response (the response scale defined by the range 0 (no change in redistribution) – 100%) of the assay by more than a predetermined value, typically between 10 and 100%, are considered to be "primary hits". The primary hits are then
- 10 further characterised: 1. for potency by establishing a dose-response relationship compared to the lead peptide(s) using the primary screening assay 2. for selectivity by establishing a dose-response relationship in the counterscreen or counterscreens. Primary hits that have low potency, typically when the half-maximal effect of the compound in the primary assay is achieved at a concentration of the compound between
- 15 10 and 100 micromolar, may not need testing in the counterscreen or counterscreens since the likelihood that they will be used beyond this step in the discovery project is small. Primary hits that have equal or lower potency in the primary screening assay compared to the counterscreen or counterscreens are regarded as non-selective and the likelihood that they will be used beyond this step in the discovery project is small.
- 20 Primary hits that display some degree of selectivity, typically half maximal effect in the primary screening assay at a concentration 50% or less of the concentration that gives half maximal effect in the counterscreen or counterscreens are considered interesting as the basis for further chemical synthesis or construction of new libraries of compounds and will hereafter be referred to as "primary lead compounds".
- 25 Compounds that cause a change in the quantitated response, with a response scale from 0 to 100% based on the absence of a response and the maximal response observed with the peptide leads in the primary screening assay, of the assay by more than a predetermined value are selected and called "primary hits".
- In one embodiment the predetermined value is 10%.
- 30 In another embodiment the predetermined value is 50%.
- In yet another embodiment the predetermined value is 70%.
- In one embodiment the primary hits are further characterised for potency and maximal effect by establishing a dose-response relationship and comparing that to the effects of the lead peptides using the primary screening assay and for selectivity by establishing a
- 35 dose-response relationship in the counterscreen or counterscreens.

Primary hits may be deselected by the discovery project when they display a half-maximal potency at a dose corresponding to a concentration of more than 10 micromolar or because they display a selectivity index less than 1 to 2.

Primary hits may be selected by the discovery project when they display a half-maximal  
5 potency at a dose corresponding to a concentration of 10 micromolar or less or because they display a selectivity index higher than 1 to 2, the compounds hereafter also referred to as "primary lead compounds".

A Structure-Activity Relationship (SAR) is built by iterations of compound library  
10 composition and screening to define drug candidate leads. This step is included to further improve the possibilities of finding bioactive compounds with desirable properties for treatment of the diseases or conditions of interest to the project. The primary lead compounds are here used to provide chemical structural information that can be used as the basis for composition or chemical synthesis of new, directed, compound libraries. By  
15 systematic chemical modification of part of the structure of one or more primary lead compounds new libraries are assembled. These new libraries of compounds are also investigated using the primary screening assay and counterscreen or counterscreens. Preferably, dose-response relationships are recorded for each chemical modification of the primary lead compound and compared to the primary lead compound itself. Thereby  
20 SAR is established. Among the new compounds, the ones that in this step has the best combination of potency and specificity are chosen either as the basis for a new round of compound library synthesis or composition or, as the final step of the SAR building process, as compounds that will be further for actual pharmacological effects in assay systems and animals that are relevant to the underlying physiological and  
25 pathophysiological processes of interest to the project. The latter compounds will hereafter be referred to as "drug candidate leads".

In one embodiment drug candidate leads have a half-maximal potency at a dose corresponding to a concentration of less than 1 micromolar and a selectivity index higher than 1 to 2.

30 In one embodiment the drug candidate leads have a half-maximal potency at a dose corresponding to a concentration of less than 1 micromolar and a selectivity index higher than 1 to 10.

In one embodiment the drug candidate leads have a half-maximal potency at a dose corresponding to a concentration of less than 1 micromolar and a selectivity index higher  
35 than 1 to 100.

In one embodiment the drug candidate leads have a half-maximal potency at a dose corresponding to a concentration of less than 0,1 micromolar and a selectivity index higher than 1 to 2.

In a preferred embodiment the drug candidate leads have a half-maximal potency at a dose corresponding to a concentration of less than 0,1 micromolar and a selectivity index higher than 1 to 10.

In another preferred embodiment the drug candidate leads have a half-maximal potency at a dose corresponding to a concentration of less than 0,1 micromolar and a selectivity index higher than 1 to 100.

10

Drug candidate leads may be further characterised in tissue based, cell based and biochemical assays to validate *in vitro* their efficacy and toxicity. There are many ways to test efficacy of a drug candidate lead. Preferably, the drug candidate lead is tested in assay systems with high relevance to the underlying physiological and

15 pathophysiological processes involved in the pathogenesis and pathophysiology of the disease or condition of interest to the project. Likewise, the drug candidate leads are tested for toxic effects, preferably testing for genetic effects (influence on the integrity and arrangement of DNA), metabolic effects (influence on cellular metabolic processes) and cytotoxic effects (influence on cell integrity and organelle integrity). There is a high  
20 likelihood that drug candidate leads, that do not show appropriate efficacy or that display toxicity will not be used beyond this step in the discovery project because it is expected that such compounds are less suitable as actual drugs to be used in an animal.

In one embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying  
25 physiological and pathophysiological processes involved in hypotension, inflammatory diseases, and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In another embodiment drug candidate leads chosen by the discovery project are tested  
30 *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying physiological and pathophysiological processes involved in inflammatory airway diseases, and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In another embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying physiological and patophysiological processes involved in inflammatory joint diseases, and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter  
5 the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In another embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying physiological and patophysiological processes involved in inflammatory bowel diseases,  
10 and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In another embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying  
15 physiological and patophysiological processes involved in autoimmune diseases, and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

20 In a preferred embodiment of the present invention I-kappaB degradation is inhibited by a novel mechanism namely by mis-targeting and/or modulation of the redistribution of specific IKKs. In contrast to previous interventions involving IKK the presented invention does not involve direct inhibition of the IKK enzymatic activity.

25 This completely novel mechanism for inhibition of the overall effect of the IKK complex provides clear advantages as it opens for a higher IKK isoform selectivity and a higher cell specificity of the therapy. In addition cell specific anchoring will allow design of compounds that only affect defined cell types.

30 In one aspect of the invention the substance is an organic compound, the organic compound being a weak acid in that it is a neutral molecule that can reversibly dissociate into an anion (a negatively charged molecule) and a proton (a hydrogen ion). In another aspect, the organic compound is a weak base in that it is a neutral molecule that can form a cation (a positively charged molecule) by combining with a proton. The functional  
35 groups of the targeting sequences include functional groups selected from the group

consisting of: methyl-, isopropyl-, isobutyl-, hydroxyl-, thiol-, benzyl-, benzyloyl-, methylindolyl-, methylimidazolyl-, amine-, imine-, carboxyl- and acetamide-groups as parts of amino acids in the targeting sequences.

- 5 In another aspect of the invention the organic compound is a compound having one or more chemical domains capable of interacting with one or more functional groups of the targeting sequence of the native anchoring site of the cyclic nucleotide phosphodiesterase or I-kappaB kinase. In yet another aspect the organic compound is a compound having at least two chemical domains capable of interacting with at least two
- 10 functional groups of the targeting sequence of the native anchoring site for the cyclic nucleotide phosphodiesterase or I-kappaB kinase. In a further aspect the organic compound is a compound having at least three chemical domains capable of interacting with at least three functional groups of the targeting sequence of the native anchoring site for the cyclic nucleotide phosphodiesterase or I-kappaB kinase.

15

- The organic compound is, in one aspect of the invention, a compound having at least two chemical domains capable of interacting with at least two functional groups of the targeting sequence of the cyclic nucleotide phosphodiesterase. In a specific embodiment, the organic compound is a compound having at least three chemical
- 20 domains capable of interacting with at least three functional groups of the targeting sequence of the cyclic nucleotide phosphodiesterase.

- In the next part of the discovery process the drug candidate leads are tested *in vivo* for toxic and unwanted effects in animals such as mice and rats. The drug candidate leads
- 25 are also tested for efficacy in animals that have a disease or condition with high degree of relevance to the disease or condition of interest to the project. The drug candidate leads may also be tested for efficacy in animals which have been treated in a way that make them experience a disease or condition with high degree of relevance to the disease or condition of interest to the project. Drug candidate leads that display efficacy
- 30 in one or more of such animal tests and that does not display any apparent toxicity at a dosage level, preferably 2 –10 times higher than the level that gives satisfactory efficacy are chosen to be the final drug candidates that should be considered for further animal testing and initial testing in humans. These compounds are hereafter referred to as "discovery project leads".

35

In one embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying physiological and pathophysiological processes involved in depression, and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug

5 candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In another embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying physiological and pathophysiological processes involved in jet-lag, and for toxicity,

10 preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In another embodiment drug candidate leads chosen by the discovery project are tested *in vitro* for efficacy, in assay systems with high degree of relevance to the underlying

15 physiological and patophysiological processes involved in erectile dysfunction, and for toxicity, preferably testing for genetic, metabolic and cytotoxic effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity are chosen to be the candidates that will enter testing in animals.

In one embodiment drug candidate leads chosen by the discovery project are tested for  
20 efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in hypotension, and for toxicity and unwanted side effects, after which the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter  
25 further testing in animals and testing in humans.

In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in inflammatory diseases, and for toxicity and unwanted side effects, after which the drug candidate  
30 leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to  
35 the underlying physiological and pathophysiological processes, involved in hypertension,

and for toxicity and unwanted side effects, after which the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

- 5 In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in jet-lag and circadian rhythm resetting, and for toxicity and unwanted side effects, after which the drug candidate leads that display the best efficacy and the least, or no, indications of
- 10 toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

- In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in erectile
- 15 dysfunction, and for toxicity and unwanted side effects, after which the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

- 20 In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in inflammatory airway diseases, and for toxicity and unwanted side effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity
- 25 or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

- In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in inflammatory
- 30 joint diseases, and for toxicity and unwanted side effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

- In one embodiment drug candidate leads chosen by the discovery project are tested for
- 35 efficacy, in healthy animals and animals with a condition with high degree of relevance to

the underlying physiological and pathophysiological processes involved in inflammatory bowel diseases, and for toxicity and unwanted side effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, 5 that will enter further testing in animals and testing in humans.

In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to the underlying physiological and pathophysiological processes involved in autoimmune diseases, and for toxicity and unwanted side effects, whereafter the drug candidate 10 leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

In one embodiment drug candidate leads chosen by the discovery project are tested for efficacy, in healthy animals and animals with a condition with high degree of relevance to 15 the underlying physiological and pathophysiological processes involved in depression, and for toxicity and unwanted side effects, whereafter the drug candidate leads that display the best efficacy and the least, or no, indications of toxicity or unwanted side effects are chosen to be the candidates, called discovery project leads, that will enter further testing in animals and testing in humans.

20

The administration route of any of the compounds of the invention may be of any suitable route which leads to a concentration in the blood corresponding to a therapeutic concentration by the oral route, the parenteral route, the cutaneous route, the nasal route, the rectal route, the vaginal route and the ocular route. It should be clear to a 25 person skilled in the art that the administration route is dependant on the compound in question, particularly, the choice of administration route depends on the physico-chemical properties of the compound together with the age and weight of the patient and on the particular disease and the severity of the same.

The compounds of the invention may be contained in any appropriate amount in a 30 pharmaceutical composition, and are generally contained in an amount of about 1-95% by weight of the total weight of the composition. The composition may be in form of, e.g., tablets, capsules, pills, powders, granulates, suspensions, emulsions, solutions, gels including hydrogels, pastes, ointments, creams, plasters, drenches, delivery devices, suppositories, enemas, injectables, implants, sprays, aerosols and in other suitable form. 35 The pharmaceutical compositions may be formulated according to conventional

pharmaceutical practice, see, e.g., "Remington's Pharmaceutical Sciences" and "Encyclopedia of Pharmaceutical Technology".

- Pharmaceutical compositions according to the present invention may be formulated to release the active compound substantially immediately upon administration or at any
- 5 substantially predetermined time or time period after administration. The latter type of compositions are generally known as controlled release formulations. Controlled release formulations may also be denoted "sustained release", "prolonged release", "programmed release", "time release", "rate-controlled" and/or "targeted release" formulations.
- 10 In the present context every pharmaceutical composition is an actual drug delivery system, since upon administration it presents the active drug substance to the body of the organism.

- The compounds of the invention are preferably administered in an amount of about 0.1-15
- 30 mg per kg body weight per day, such as about 0.5-15 mg per kg body weight per day. The compound in question may be administered orally in the form of tablets, cap-sules, elixirs or syrups, or rectally in the form of suppositories. Parenteral administration of the compounds of the invention, is suitably performed in the form of saline solutions of the compounds or with the compound incorporated into liposomes. In cases where the
- 20 compound in itself is not sufficiently soluble to be dissolved, an acid addition salt of a basic compound can be used, or a solubilizer such as ethanol can be applied.
- Oral administration. For compositions adapted for oral administration for systemic use, the dosage is normally 1 mg to 1 g per dose administered 1-4 times daily for 1 week, 12 months or even lifelong depending on the disease to be treated.

- 25 Rectal administration. For compositions adapted for rectal a somewhat higher amount of compound is usually preferred, i.e. from approximately 1 mg to 100 mg per kg body weight per day.

- Parenteral administration. For parenteral administration a dose of about 0.1 mg to about 50 mg per kg body weight per day is convenient. For intravenous administration a dose
- 30 of about 0.1 mg to about 20 mg per kg body weight per day. For intraarticular administration a dose of about 0.1 mg to about 20 mg per kg body weight per day is usually preferable. For parenteral administration in general, a solution in an aqueous medium of 0.5-2% or more of the active ingredients may be employed.

- Cutaneous administration. For topical administration on the skin a dose of about 1 mg to
- 35 about 5 g administered 1-10 times daily is usually preferable.

## EXAMPLES

### *Example 1: Probes for detection of PDE4D dislocation.*

These are specific PDE4D variants fused to a GFP. Currently 5 PDE4D splice variants are known: PDE4D1, PDE4D2, PDE4D3, PDE4D4 and PDE4D5. These all share C-terminal sequences but differ in their N-termini.

Inspection of the scientific literature indicates that the PDE4D1 and PDE4D2 subtypes are found only in the cytosolic fraction, whereas PDE4D3, PDE4D4 and PDE4D5 subtypes appear to associate with some form of cellular structure(s). Targetting sequences of PDE4Ds are presently believed to be located in their N-terminal domain(s).

In accordance with this, PDE4D1 and PDE4D2 have much shorter N-terminal domains than PDE4D3, PDE4D4 and PDE4D5. To best preserve the normal distribution of PDE4Ds, the fusions are made between the C-terminus of the PDE4D species and the N-terminal of the GFP.

To construct PDE4D-GFP fusions, PDE4D sequences are amplified using PCR according to standard protocols with specific top-primers as listed below, and the common bottom-primer listed below. The PCR products are digested with restriction enzymes Hind3 and EcoR1, and ligated into pEGFP-N1 (Clontech, Palo Alto; GenBank Accession number U55762) digested with Hind3 and EcoR1. This produces PDE4D-EGFP fusions under the control of a CMV promoter (SEQ ID NOs: 5 and 6 (PDE4D5-EGFP); SEQ ID NOs: 3 and 4 (PDE4D4-EGFP); SEQ ID NOs: 1 and 2 (PDE4D3-EGFP)).

Top primers all include specific sequences following the ATG, a Kozak sequence, and a cloning site (Hind3). The bottom primer includes the common C-terminal sequence minus the stop codon, an EcoR1 cloning site, and an extra nucleotide to preserve the reading frame in EGFP-N1.

Sequences of top-primers:

5'-GTAAGCTTCGAACATGATGCACGTGAATAATTTTCCC-3' ; specific for PDE4D3A and PDE4D3B (GenBank Acc. nos. L20970 & U50159).

5'-GTAAGCTTCGAACATGGAGGCAGAGGGCAGCAGC-3'; specific for PDE4D4A (GenBank Acc. no. L20969).

5'-GTAAGCTTCGAACATGGCTCAGCAGACAAGCCCG-3'; specific for PDE4D5A (GenBank Acc. no. AF012073).

Sequence of common bottom-primer:

5 5'-GTGAATTCCTCGTGTCTCAGGAGAAGCATCATCTATG-3'.

The resulting plasmids are transfected into a suitable cell line, e.g. MVLEC. The subcellular distribution of the probes is examined carefully by fluorescence microscopy, both under resting conditions, and upon elevation of cAMP, e.g. by activation of  
10 adenylate cyclase with forskolin, which may or may not have an effect on the normal distribution.

**Example 2: Probes for detection of PDE5 dislocation:**

These are specific PDE5 variants fused to a GFP. Currently only one main human variant is known (GenBank Acc.nos. AJ004865 and D89094).

15 Inspection of the scientific literature indicates that the catalytic domain is contained in the C-terminal part of the protein, so potential targeting sequences of PDE5 may be located in the N-terminal part. To best preserve the normal distribution of PDE5, the first fusion is made between the C-terminus of the PDE5 species and the N-terminal of the GFP.

20 To construct the PDE5-GFP fusions, PDE5 sequences are amplified using PCR according to standard protocols with the specific primers listed below. The PCR product is digested with restriction enzymes EcoR1 and Acc65I, and ligated into pEGFP-N1 (Clontech, Palo Alto; GenBank Accession number U55762) digested with EcoR1 and Acc65I. This produces a PDE5-EGFP fusion under the control of a CMV promoter (SEQ  
25 ID NOs: 7 and 8).

The top primer includes specific sequences following the ATG, a Kozak sequence, and a cloning site (EcoR1). The bottom primer includes specific C-terminal sequences minus the stop codon, an Acc65I cloning site, and two extra nucleotides to preserve the reading frame in EGFP-N1.

30

PDE5-top :

5'-GTGAATTC AACCATGGAGCGGGCC-3'

PDE5-bottom:

35 5'-GTGGTACCCAGTTCGCTTGGCC

The resulting plasmids are transfected into a suitable cell line, e.g. MVLEC. The subcellular distribution of the probes is examined carefully by fluorescence microscopy, both under resting conditions, and upon elevation of cGMP, e.g. by activation of cyclase  
5 with NO or nitroprusside, which may or may not have an effect on the normal distribution.

**EXAMPLE 3: Probes for detection of IKK redistribution.**

Modulation of IKK $\beta$  redistribution by mis-targeting provoke an inhibition of cytokine-induced NF-kappaB activation. In the present example it is shown that specific mis-tageting of IKK $\beta$  inhibits cytokine-induced NF-kappaB activation. Dislocation of  
10 endogenous IKK $\beta$  from its anchoring sites is achieved by expression of a C-terminal part of IKK $\beta$  (PS473). The PS473 probe, which is a GFP fusion, allows a simultaneous monitoring of its localisation and redistribution.

Expression of the PS473 probe has a clear inhibitory activity on cytokine-induced  
15 activation of NF-kappaB. For the first time we hereby show that dislocating IKK $\beta$ , without directly affecting its kinase activity, effectively hampers the functional activity of NF-kappaB. This causal relationship between mis-targeting of IKK $\beta$  and a lacking NF-kappaB activity is studied in two different systems: a) Real-time measurement of NF-kappaB translocation from the cytoplasm to the nucleus, and b) measurement of NF-  
20 kappaB induced transcriptional activity.

These are specific IKK subunit variants fused to a GFP. As examples, the following three subunits have been chosen: IKK $\alpha$  (GenBank Acc.no. AF009225) , IKK $\beta$  (GenBank Acc. No. AF031416), IKK $\gamma$  (GenBank Acc. No. AF074382) and NIK (GenBank Acc. No.  
25 NM003954).

Inspection of the scientific literature indicates that IKK $\beta$  dissociates transiently from the IKAP complex during activation, and so becomes the first choice for a probe to detect redistribution.

To construct the IKK $\beta$ -GFP fusion, IKK $\beta$  sequences are amplified using PCR according  
30 to standard protocols with the specific primers listed below. The PCR product is digested with restriction enzymes Hind3 and Acc65I, and ligated into pEGFP-N1 (Clontech, Palo Alto; GenBank Accession number U55762) digested with Hind3 and Acc65I. This produces an IKK $\beta$ -EGFP fusion under the control of a CMV promoter (SEQ ID NOs: 9 and 10).

The top primer includes specific sequences following the ATG and a cloning site (Hind3). The bottom primer includes specific C-terminal sequences minus the stop codon, an Acc65I cloning site, and two extra nucleotides to preserve the reading frame in EGFP-N1.

5

IKK $\beta$ -top:

5'-GTAAGCTTACATGAGCTGGTCACCTTCCCTG-3'

IKK $\beta$ -bottom:

10 5'-GTGGTACCCATGAGGCCTGCTCCAG-3'

The resulting plasmids are transfected into a suitable cell line. The subcellular distribution of the probes is examined carefully by fluorescence microscopy, both under resting conditions, and upon activation, e.g. with TNF $\alpha$ .

15

Probes for detection of activation of the NFkappaB signal transduction pathway.

Plasmid PS377 contains an NFkappaBp65-EGFP fusion. The GenBank accession number of the p65 subunit of NFkappaB is M62399. It is constructed by performing PCR on human cDNA (from Clontech) with specific primers p65-top and p65-bottom. The resulting ca. 1.7 kb PCR product is cut with restriction enzymes Xho1 and Hind3 and cloned into pEGFP-N1 (Clontech) cut with Xho1 and Hind3. This produces an NFkappaB-EGFP fusion (SEQ ID NOs: 11 and 12) under the control of the CMV promoter.

25

p65-top: 5'-TTTACTCGAGATGGACGAAGTGTCCCCCTCA-3'

p65-bottom: 5'-TTTGAAGCTTGGAGCTGATCTGACTCAGCAGG-3'

Construction of a reporter gene assay for monitoring NFkappaB-induced transcriptional activation:

30

Plasmid PS397 contains a selectable NFkappaB reporter construct. It is constructed through ligation of two BamH1-Not1 fragments: A 2.4 kb fragment from pNFkappaB-Luc (from Clontech), which contains a luciferase gene and NFkappaB response elements, and a 2.8 kb BamH1-Not1 fragment from pZeoSV (from Invitrogen), which contains

essential plasmid elements and a zeocin selective marker for use in *E. coli* and mammalian cells.

Construction of probes for monitoring IKK $\beta$  localisation, mis-targeting and redistribution

5 in live cells:

- Plasmid PS410 contains an EGFP-IKK $\beta$  fusion. The GenBank accession number of the beta subunit of IkappaB kinase is AF031416. It is constructed by performing PCR on human cDNA (from Clontech) with specific primers IKK $\beta$ -top and IKK $\beta$ -stop. The resulting 2.2 kb PCR product is cut with restriction enzymes Hind3 and Acc65I and
- 10 cloned into pEGFP-C1 (Clontech) cut with Hind3 and Acc65I. This produces an EGFP-IKK $\beta$  fusion (SEQ ID NOs: 13 and 14) under the control of the CMV promoter.

IKK $\beta$ -top: 5'-GTAAGCTTACATGAGCTGGTCACCTCCCTG-3'

IKK $\beta$ -stop: 5'-GTGGTACCTCATGAGGCCTGCTCCAG-3'

15

- Plasmid PS472 contains a full length IKK $\beta$  under the control of the CMV promoter. It is constructed by cutting PS410 with restriction enzymes Nhe1 and Hind3, which flank EGFP. This excises EGFP sequences from the plasmid, while placing IKK $\beta$  immediately downstream of the CMV promoter. The protruding ends generated by the enzymes are
- 20 then made blunt using Klenow polymerase according to standard protocol, and the plasmid is recircularized with DNA ligase.

- PS473 contains EGFP fused to the C-terminal part of IKK $\beta$ . This part of IKK $\beta$  contains a putative leucine zipper region, but is without catalytic activity as this function resides in
- 25 the N-terminal part of IKK $\beta$ . It is constructed by performing PCR on PS410 with primers IKK $\beta$ -LZ-top and IKK $\beta$ -stop. IKK $\beta$ -LZ-top contains a Hind3 site and specific IKK $\beta$  sequence from amino acid position 455 in the predicted amino acid sequence. This is almost immediately upstream of the first leucine of the predicted leucine zipper, which is at position 458. The resulting 0.9 kb PCR product is cut with restriction enzymes Hind3
- 30 and Acc65I and cloned into pEGFP-C1 (Clontech) cut with Hind3 and Acc65I. This produces an EGFP-IKK $\beta$ -LZdomain fusion (SEQ ID NOs: 15 and 16) under the control of the CMV promoter.

IKK $\beta$ -LZ-top: 5'-GTAAGCTTCCACCATGATGAATCTCCTCCGAAAC-3'

35

Plasmid PS474 contains the IKK $\beta$  C-terminal part under the control of the CMV promoter. It is constructed by cutting PS473 with restriction enzymes Age1 and BspE1, which flank EGFP. This excises EGFP sequences from the plasmid, while placing IKK $\beta$  sequences immediately downstream of the CMV promoter. As Age1 and BspE1 produce  
5 compatible ends, the plasmid is simply recircularized with DNA ligase. The ATG methionine codon at position 455 in the predicted amino acid sequence of IKK $\beta$ , may serve as initiation codon in this construct.

Transfections and cell culture conditions.

- 10 Chinese hamster ovary cells (CHO), Human epithelial kidney cells (HEK293) and Human epithelial adenocarcinoma cells (HeLa), were transfected with above mentioned plasmids using FuGENE transfection reagent (Boehringer Mannheim). Stable transfectants were selected using 1000  $\mu$ g Zeocin/ml (Invitrogen) or 500  $\mu$ g G418/ml (Neo marker) in the growth medium [DMEM (HEK293 and HeLa) or HAM F12 (CHO)  
15 with 1000 mg glucose/l, 10 % fetal bovine serum (FBS), 100  $\mu$ g penicillin-streptomycin mixture ml<sup>-1</sup>, 2 mM L-glutamine purchased from Life Technologies Inc., Gaithersburg, MD, USA).

- For fluorescence microscopy, cells were allowed to adhere to Lab-Tek chambered coverglasses (Nalge Nunc Int., Naperville, IL, USA) for at least 24 hours and cultured to  
20 about 80% confluence. Prior to experiments, the cells were cultured over night without selection pressure in DMEM or HAM F-12 medium with glutamax (Life Technologies), 100  $\mu$ g penicillin-streptomycin mixture ml<sup>-1</sup> and 0.3 % FBS. This medium has low autofluorescence enabling fluorescence microscopy of cells straight from the incubator.

- 25 Microscope imaging of localisation and redistribution in live cells:

Image aquisition of live cells were gathered using a Zeiss Axiovert 135M fluorescence microscope fitted with a Fluor 40X, NA: 1.3 oil immersion objective and coupled to a Photometrics CH250 charged coupled device (CCD) camera. The cells were illuminated with a 100 W HBO arc lamp. For imaging of GFP-based probes we  
30 inserted in the light path was a 470 $\pm$ 20 nm excitation filter, a 510 nm dichroic mirror and a 515 $\pm$ 15 nm emission filter. For imaging of the Hoechst 33342 (H1399, Molecular Probes) nuclear stain we used a 380 $\pm$ 20 nm excitation filter, a 410 nm dichroic mirror and a 555 $\pm$ 15 nm emission filter

The cells were kept and monitored to be at 37°C with a custom built stage heater.

#### Quantification of NF-kappaB redistribution:

Cells are stained with the vital nuclear stain, Hoechst.

A sequence of images with a time separation of 10 sec is acquired. At each time point the sequence consists of one NF-kappaB-GFP image and one image of the Hoechst

5 stained nucleus.

The image sequence is corrected for dark current by performing a pixel-by-pixel subtraction of a dark image (an image taken under the same conditions as the actual image, except the camera shutter is not allowed to open).

10 The image sequence is corrected for non-uniformity of the illumination by performing a pixel-by-pixel ratio with a flat field correction image (an image taken under the same conditions as the actual image of a uniformly fluorescent specimen).

At each time point the accumulated intensity of the NFkappaB probe in the nucleus is ratioed over the total cytoplasmic intensity. The Hoechst image is used to mask the nucleus.

15

#### Results:

The full length IKK $\beta$  probe (PS410) show an even distribution throughout the cytoplasm when expressed in CHO (Fig. 2) and HEK293 cells. PS473 show a similar localisation after its expression (Fig. 3A). Interestingly however the probe has sensitised the cells to

20 stimuli that induce apoptosis. It is thus observed that the PS473 expressing cells upon 2 hrs of serum starvation undergo apoptosis, in comparison non-transfected cells or PS410 expressing cells did show no sign on apoptosis after similar treatment. The induction of apoptosis could be visualised as a change in the localisation of the PS473 probe from an even distribution throughout the cytoplasm to a discrete punctate localisation (Fig. 3B).

25

The PS473 provoked mis-targeting of IKK $\beta$  had pronounced functional consequences. We thus observed a prominent inhibition of IL-1 induced NFkappaB redistribution (Fig. 4). Furthermore we observed an inhibition of IL-1 and TNF $\alpha$  induced activation of the NFkappaB regulated transcription as monitored with the above described luciferase

30 reporter construct (PS397) (Fig. 5).

## Figur legends

### Figure 1

CHO cells expressing PS377 for monitoring NFkappaB redistribution in live cells. A) Before stimulation and B) 10 minutes after stimulation with IL-1 (10 ng/ml).

5

### Figure 2

The full length IKK $\beta$  probe (PS410) show an even distribution throughout the cytoplasm when expressed in CHO cells.

### 10 Figure 3

PS473 expressed in CHO cells. (A) show an even distribution throughout the cytoplasm. (B) The distributaion change when cells undergo appoptosis as observed after two hours of serum starvation.

### 15 Figure 4

Expression of PS473 inhibits IL-1 (0.5 ng/ml) induced redistribution of NF-kappaB in CHO cells.

### Figure 5

### 20 Expression of PS473 inhibits IL-1 (0.5 ng/ml) and TNF- $\alpha$ (0.5 ng/ml) induced NF-kappaB regulated transcription in HEK293 cells.

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## Claims

1. Use of a substance, capable of modulating the specific effectiveness of a cyclic nucleotide phosphodiesterase or I-kappaB kinases through modulating the spatial  
5 distribution or change in spatial distribution of the cyclic nucleotide phosphodiesterases or I-kappaB kinases within cells of an animal, for the preparation of a medicament for the prevention or treatment in an animal of an adverse condition which may be reduced or abolished by modulating the activity of one or more cyclic nucleotide phosphodiesterases having the ability to cleave cyclic AMP or cyclic GMP or by  
10 modulating the activity of one or more I-kappaB.
2. Use according to claim 1, wherein the I-kappaB kinase is selected from the group consisting of I-kappaB kinase  $\alpha$ , I-kappaB kinase  $\beta$ , I-kappaB kinase  $\gamma$  and NIK.
- 15 3. Use according to claim 2, wherein the I-kappaB kinase is I-kappaB kinase  $\beta$ .
4. Use according to claim 1, wherein the cyclic nucleotide phosphodiesterase is selected from the group consisting of PDE3, PDE4, PDE7 and PDE8.
- 20 5. Use according to claim 4, wherein the cyclic nucleotide phosphodiesterase is PDE4.
6. Use according to claim 5, wherein the cyclic nucleotide phosphodiesterase is a splice variant of PDE4, selected from the group consisting of PDE4A, PDE4B, PDE4C and PDE4D.
- 25 7. Use according to claim 6, wherein the PDE4 species is a splice variant of PDE4D.
8. Use according to claim 7, wherein the splice variant is PDE4D1, PDE4D2, PDE4D3, PDE4D4, PDE4D5 and PDE4A1.
- 30 9. Use according to claim 8, wherein the splice variant is PDE4D3, PDE4D4 or PDE4D5.
10. Use according to claim 6, wherein the PDE4 splice variant is PDE4A1.

11. Use according to any of the preceding claims, wherein the adverse condition is an inflammatory diseases such as chronic inflammation.
12. Use according to any of claims 1-10, wherein the adverse condition is chronic  
5 inflammatory airway diseases such as asthma and chronic bronchial hyperreactivity of non-asthma etiology.
13. Use according to any of claims 1-10, wherein the adverse condition is chronic inflammatory joint diseases such as rheumatoid arthritis and pelvospondylitis.
- 10 14. Use according to any of claims 1-10, wherein the adverse condition is chronic inflammatory bowel diseases such as ulcerative colitis and Crohn's disease.
15. Use according to any of claims 1-10, wherein the adverse condition is autoimmune  
15 diseases with chronic inflammation such as rheumatoid arthritis, diabetes mellitus type I, systemic lupus erythematosus, myasthenia gravis, Hashimoto's thyroiditis, Graves' disease and immune thrombocytopenic purpura.
16. Use according to any of claims 1-10, wherein the adverse condition involves a  
20 disregulation of the immune system such as acute respiratory distress syndrome (ARDS) and septic shock.
17. Use according to claim 10, wherein the adverse condition is depression.
- 25 18. Use according to claim 1, wherein the cyclic nucleotide phosphodiesterase is selected from the group consisting of PDE1, PDE2, PDE5, PDE6, PDE9 and PDE10.
19. Use according to claim 18, wherein the nucleotide phosphodiesterase is a splice  
variant of PDE5.
- 30 20. Use according to claim 18 or 19, wherein the adverse condition is hypo- or hypertension, erectile dysfunction, circadian rhythm resetting or jet-lag.
21. Use according to any of the preceding claims wherein the animal is a mammal.
- 35

22. Use according to claim 21, wherein the mammal is a human being.

23. Use according to any of the preceding claims, wherein the substance is an organic compound having a molecular weight of around 3000 Da

5

24. Use according to any of claims 1-22, wherein the substance is an organic compound having a molecular weight of at the most 1200 Da.

25. Use according to claim 24, wherein the substance is an organic compound having a  
10 molecular weight of at the most 900 Da.

26. Use according to claim 25, wherein the substance is an organic compound having a molecular weight of at the most 600 Da.

15 27. Use according to claim 26, wherein the substance is an organic compound having a molecular weight of at the most 300 Da.

28. Use according to any of the preceding claims, wherein the substance is a peptide.

20 29. Use according to any of claim 1-27, wherein the substance is a carbon-containing non-peptide.

30. Use according to any of the preceding claims, wherein the organic compound is a compound having one or more chemical domains capable of interacting with one or  
25 more functional groups of the targeting sequence of the native anchoring site of the cyclic nucleotide phosphodiesterase or I-kappaB kinase.

31. Use according to any of the preceding claims, wherein the substance interacts with the targeting sequence or part thereof in a manner that dislocates, disrupts targeting, or  
30 interferes with redistribution of the fluorescent probe as measured in quantitative fluorescence redistribution assay.

32. A method for extracting quantitative information relating to an influence on a cellular response, the method comprising recording variation, caused by the influence on a  
35 mechanically intact living cell or mechanically intact living cells, in spatially distributed

light emitted from a luminophore, the luminophore being part of a fluorescent probe further comprising at least a part of a cyclic nucleotide phosphodiesterase or I-kappaB kinase, the fluorescent probe being present in the cell or cells and being capable of being redistributed in a manner which is related with the degree of the influence, and/or  
5 of being modulated by a component which is capable of being redistributed in a manner which is related to the degree of the influence, the association resulting in a modulation of the luminescence characteristics of the luminophore, and processing the recorded variation in the spatially distributed light to provide quantitative information correlating the spatial distribution to the degree of the influence on the cellular response.

10

33. A screening assay for carrying out the method of claim 32.

34. A screening assay according to claim 32 or 33 wherein the fluorescent probe is modified in a systematic way, still keeping the GFP coding sequence intact, so that the  
15 new fluorescent probes are fusion polypeptides where parts of the suspected targeting sequences are altered.

35. A screening assay according to claim 34, wherein the modification of the suspected targeting sequence is a deletion.

20

36. A screening assay according to any of claims 33-35, wherein the spatial distribution of the fluorescent probe is compared to the spatial distribution of the unmodified fluorescent probe to deduce the targeting sequence.

25 37. A screening assay according to any of claims 33-36, wherein the quantitative fluorescence redistribution assay is a primary screening assay used in a discovery project

38. A nucleotide sequence encoding the protein corresponding to amino acids 331-552  
30 of SEQ ID NO: 16 or any sub-sequence thereof of more than 25 contiguous amino acids, able to dislocate IKK $\beta$  when expressed in CHO cells under the control of the CMV promoter.

39. A nucleotide sequence according to claim 38, wherein the sub-sequence is the  
35 predicted leucine zipper contained in amino acids 331-360 of SEQ ID NO: 16.

40. A screening assay according to any of claims 33-37, wherein the fluorescent probe comprises a nucleotide sequence according to claim 38 or 39.

5 41. A method according to claim 32 wherein the fluorescent probe is able to dislocate IKK $\beta$  when expressed in CHO cells under the control of the CMV promoter.

42. A method for preventing or treating, in an animal in need thereof, an adverse condition which may be reduced or abolished by modulating the activity of one or more  
10 cyclic nucleotide phosphodiesterases having the ability to cleave cyclic AMP, or cyclic AMP, or by modulating the activity of one or more I-kappaB kinases, the method comprising modulating the specific effectiveness of the cyclic nucleotide phosphodiesterase or I-kappaB kinase by modulating the spatial distribution within cells of the animal.

## Figures

Fig. 1A

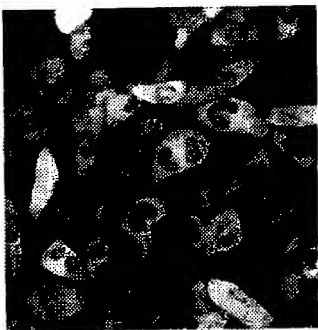


Fig. 1B

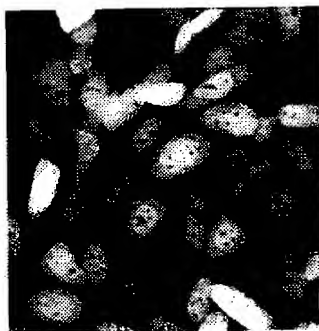


Fig. 2

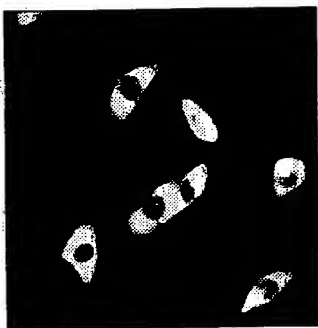


Fig. 3A



Fig. 3B

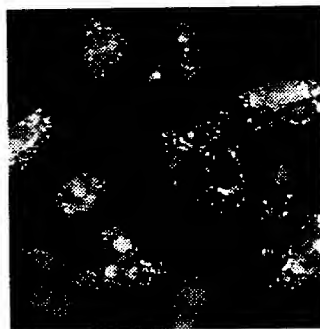


Fig. 4

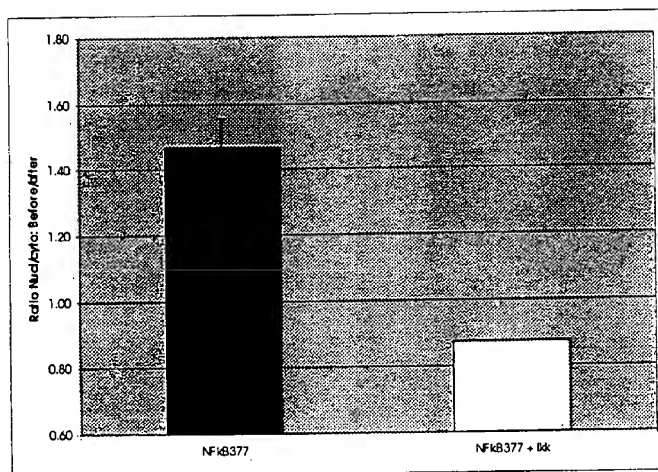
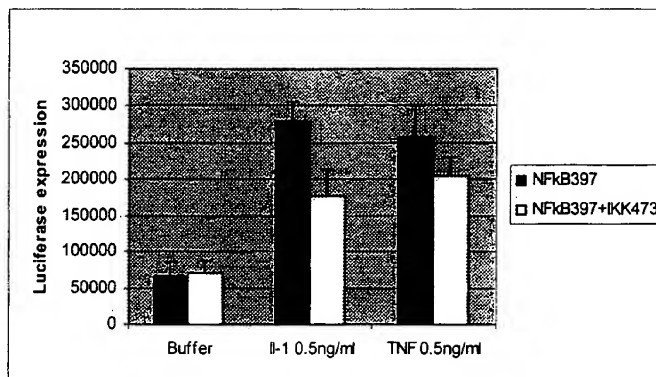


Fig. 5



## SEQUENCE LISTING

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&lt;160&gt; 16

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&lt;211&gt; 2793

&lt;212&gt; DNA

&lt;213&gt; Aequorea victoria and human

&lt;220&gt;

&lt;221&gt; CDS

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Gly Gln Thr Glu Lys Phe Gln Phe Glu Leu Thr Leu Glu Glu Asp Gly		590
	595	600
Glu Ser Asp Thr Glu Lys Asp Ser Gly Ser Gln Val Glu Glu Asp Thr		605
	610	615
Ser Cys Ser Asp Ser Lys Thr Leu Cys Thr Gln Asp Ser Glu Ser Thr		620
625	630	635
Glu Ile Pro Leu Asp Glu Gln Val Glu Glu Glu Ala Val Gly Glu Glu		640
	645	650
Glu Glu Ser Gln Pro Glu Ala Cys Val Ile Asp Asp Arg Ser Pro Asp		655
	660	665
Thr Thr Gly Ile Leu Gln Ser Thr Val Pro Arg Ala Arg Asp Pro Pro		670
675	680	685

Val Ala Thr Met Val Ser Lys Gly Glu Glu Leu Phe Thr Gly Val Val  
 690 695 700  
 Pro Ile Leu Val Glu Leu Asp Gly Asp Val Asn Gly His Lys Phe Ser  
 705 710 715  
 Val Ser Gly Glu Gly Glu Gly Asp Ala Thr Tyr Gly Lys Leu Thr Leu  
 725 730 735  
 Lys Phe Ile Cys Thr Thr Gly Lys Leu Pro Val Pro Trp Pro Thr Leu  
 740 745 750  
 Val Thr Thr Leu Thr Tyr Gly Val Gln Cys Phe Ser Arg Tyr Pro Asp  
 755 760 765  
 His Met Lys Gln His Asp Phe Phe Lys Ser Ala Met Pro Glu Gly Tyr  
 770 775 780  
 Val Gln Glu Arg Thr Ile Phe Phe Lys Asp Asp Gly Asn Tyr Lys Thr  
 785 790 795 800  
 Arg Ala Glu Val Lys Phe Glu Gly Asp Thr Leu Val Asn Arg Ile Glu  
 805 810 815  
 Leu Lys Gly Ile Asp Phe Lys Glu Asp Gly Asn Ile Leu Gly His Lys  
 820 825 830  
 Leu Glu Tyr Asn Tyr Asn Ser His Asn Val Tyr Ile Met Ala Asp Lys  
 835 840 845  
 Gln Lys Asn Gly Ile Lys Val Asn Phe Lys Ile Arg His Asn Ile Glu  
 850 855 860  
 Asp Gly Ser Val Gln Leu Ala Asp His Tyr Gln Gln Asn Thr Pro Ile  
 865 870 875 880  
 Gly Asp Gly Pro Val Leu Leu Pro Asp Asn His Tyr Leu Ser Thr Gln  
 885 890 895  
 Ser Ala Leu Ser Lys Asp Pro Asn Glu Lys Arg Asp His Met Val Leu  
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 Tyr Lys  
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 Gly Ser Asp Ser Ala Gly Gly Ala Thr Leu Lys Ala Pro Lys His Leu  
 20 25 30  
 tgg agg cac gag cag cac cac cag tac ccg ctc cgg cag ccc cag ttc 144  
 Trp Arg His Glu Gln His His Gln Tyr Pro Leu Arg Gln Pro Gln Phe  
 35 40 45  
 cgc ctc ctg cat ccc cat cac cac ctg ccc ccg ccg ccg cca ccc tcg 192  
 Arg Leu Leu His Pro His His His Leu Pro Pro Pro Pro Pro Pro Ser  
 50 55 60

ccc cag ccc cag ccc cag tgt ccg cta cag ccg ccg ccg ccg ccc ccc	240
Pro Gln Pro Gln Pro Gln Cys Pro Leu Gln Pro Pro Pro Pro Pro Pro	
65 70 75 80	
ctg ccg ccg ccc ccg ccg ccg ccc ggg gct gcc cgc ggc cgc tac gcc	288
Leu Pro Pro Pro Pro Pro Pro Pro Gly Ala Ala Arg Gly Arg Tyr Ala	
85 90 95	
tcg agc ggg gcc acc ggc cgc gtc ccg cat cgc ggc tac tcg gac acc	336
Ser Ser Gly Ala Thr Gly Arg Val Arg His Arg Gly Tyr Ser Asp Thr	
100 105 110	
gag cgc tac ctg tac tgt cgc gcc atg gac cgc acc tcc tac gcg gtg	384
Glu Arg Tyr Leu Tyr Cys Arg Ala Met Asp Arg Thr Ser Tyr Ala Val	
115 120 125	
gag acc ggc cac ccg ccc gcc ctg aag aaa tcc agg atg tcc tgg ccc	432
Glu Thr Gly His Arg Pro Gly Leu Lys Lys Ser Arg Met Ser Trp Pro	
130 135 140	
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Ser Ser Phe Gln Gly Leu Arg Arg Phe Asp Val Asp Asn Gly Thr Ser	
145 150 155 160	
gcg gga ccg agt ccc ttg gat ccc atg acc agc cca gga tcc ggg cta	528
Ala Gly Arg Ser Pro Leu Asp Pro Met Thr Ser Pro Gly Ser Gly Leu	
165 170 175	
att ctc caa gca aat ttt gtc cac agt caa cga ccg gag tcc ttc ctg	576
Ile Leu Gln Ala Asn Phe Val His Ser Gln Arg Arg Glu Ser Phe Leu	
180 185 190	
tat cga tcc gac agc gat tat gac ctc tct cca aag tct atg tcc ccg	624
Tyr Arg Ser Asp Ser Asp Tyr Asp Leu Ser Pro Lys Ser Met Ser Arg	
195 200 205	
aac tcc tcc att gcc agt gat ata cac gga gat gac ttg att gtg act	672
Asn Ser Ser Ile Ala Ser Asp Ile His Gly Asp Asp Leu Ile Val Thr	
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cca ttt gct cag gtc ttg gcc agt ctg cga act gta cga aac aac ttt	720
Pro Phe Ala Gln Val Leu Ala Ser Leu Arg Thr Val Arg Asn Asn Phe	
225 230 235 240	
gct gca tta act aat ttg caa gat cga gca cct agc aaa aga tca ccc	768
Ala Ala Leu Thr Asn Leu Gln Asp Arg Ala Pro Ser Lys Arg Ser Pro	
245 250 255	
atg tgc aac caa cca tcc atc aac aaa gcc acc ata aca gag gag gcc	816
Met Cys Asn Gln Pro Ser Ile Asn Lys Ala Thr Ile Thr Glu Glu Ala	
260 265 270	
tac cag aaa ctg gcc agc gag acc ctg gag gag ctg gac tgg tgt ctg	864
Tyr Gln Lys Leu Ala Ser Glu Thr Leu Glu Glu Leu Asp Trp Cys Leu	
275 280 285	
gac cag cta gag acc cta cag acc agg cac tcc gtc agt gag atg gcc	912
Asp Gln Leu Glu Thr Leu Gln Thr Arg His Ser Val Ser Glu Met Ala	
290 295 300	

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gaa atg agt cgg tct gga aat caa gtg tca gag ttt ata tca aac aca Glu Met Ser Arg Ser Gly Asn Gln Val Ser Glu Phe Ile Ser Asn Thr 325 330 335	1008
ttc tta gat aag caa cat gaa gtg gaa att cct tct cca act cag aag Phe Leu Asp Lys Gln His Glu Val Glu Ile Pro Ser Pro Thr Gln Lys 340 345 350	1056
gaa aag gag aaa aag aaa aga cca atg tct cag atc agt gga gtc aag Glu Lys Glu Lys Lys Lys Arg Pro Met Ser Gln Ile Ser Gly Val Lys 355 360 365	1104
aaa ttg atg cac agc tct agt ctg act aat tca agt atc cca agg ttt Lys Leu Met His Ser Ser Ser Leu Thr Asn Ser Ser Ile Pro Arg Phe 370 375 380	1152
gga gtt aaa act gaa caa gaa gat gtc ctt gcc aag gaa cta gaa gat Gly Val Lys Thr Glu Gln Glu Asp Val Leu Ala Lys Glu Leu Glu Asp 385 390 395 400	1200
gtg aac aaa tgg ggt ctt cat gtt ttc aga ata gca gag ttg tct ggt Val Asn Lys Trp Gly Leu His Val Phe Arg Ile Ala Glu Leu Ser Gly 405 410 415	1248
aac cgg ccc ttg act gtt atc atg cac acc att ttt cag gaa cgg gat Asn Arg Pro Leu Thr Val Ile Met His Thr Ile Phe Gln Glu Arg Asp 420 425 430	1296
tta tta aaa aca ttt aaa att cca gta gat act tta att aca tat ctt Leu Leu Lys Thr Phe Lys Ile Pro Val Asp Thr Leu Ile Thr Tyr Leu 435 440 445	1344
atg act ctc gaa gac cat tac cat gct gat gtg gcc tat cac aac aat Met Thr Leu Glu Asp His Tyr His Ala Asp Val Ala Tyr His Asn Asn 450 455 460	1392
atc cat gct gca gat gtt gtc cag tct act cat gtg cta tta tct aca Ile His Ala Ala Asp Val Val Gln Ser Thr His Val Leu Leu Ser Thr 465 470 475 480	1440
cct gct ttg gag gct gtg ttt aca gat ttg gag att ctt gca gca att Pro Ala Leu Glu Ala Val Phe Thr Asp Leu Glu Ile Leu Ala Ala Ile 485 490 495	1488
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tca gtc tta gag aac cat cat ttg gct gtg ggc ttt aaa ttg ctt cag Ser Val Leu Glu Asn His His Leu Ala Val Gly Phe Lys Leu Leu Gln	1632

530	535	540	
gaa gaa aac tgt gac att ttc cag aat ttg acc aaa aaa caa aga caa Glu Glu Asn Cys Asp Ile Phe Gln Asn Leu Thr Lys Lys Gln Arg Gln 545 550 555 560			1680
tct tta agg aaa atg gtc att gac atc gta ctt gca aca gat atg tca Ser Leu Arg Lys Met Val Ile Asp Ile Val Leu Ala Thr Asp Met Ser 565 570 575			1728
aaa cac atg aat cta ctg gct gat ttg aag act atg gtt gaa act aag Lys His Met Asn Leu Leu Ala Asp Leu Lys Thr Met Val Glu Thr Lys 580 585 590			1776
aaa gtg aca agc tct gga gtt ctt ctt ctt gat aat tat tcc gat agg Lys Val Thr Ser Ser Gly Val Leu Leu Leu Asp Asn Tyr Ser Asp Arg 595 600 605			1824
att cag gtt ctt cag aat atg gtg cac tgt gca gat ctg agc aac cca Ile Gln Val Leu Gln Asn Met Val His Cys Ala Asp Leu Ser Asn Pro 610 615 620			1872
aca aag cct ctc cag ctg tac cgc cag tgg acg gac cgg ata atg gag Thr Lys Pro Leu Gln Leu Tyr Arg Gln Trp Thr Asp Arg Ile Met Glu 625 630 635 640			1920
gag ttc ttc cgc caa gga gac cga gag agg gaa cgt gcc atg gag ata Glu Phe Phe Arg Gln Gly Asp Arg Glu Arg Gly Met Glu Ile 645 650 655			1968
agc ccc atg tgt gac aag cac aat gct tcc gtg gaa aaa tca cag gtg Ser Pro Met Cys Asp Lys His Asn Ala Ser Val Glu Lys Ser Gln Val 660 665 670			2016
ggc ttc ata gac tat att gtt cat ccc ctc tgg gag aca tgg gca gac Gly Phe Ile Asp Tyr Ile Val His Pro Leu Trp Glu Thr Trp Ala Asp 675 680 685			2064
ctc gtc cac cct gac gcc cag gat att ttg gac act ttg gag gac aat Leu Val His Pro Asp Ala Gln Asp Ile Leu Asp Thr Leu Glu Asp Asn 690 695 700			2112
cgt gaa tgg tac cag agc aca atc cct cag agc ccc tct cct gca cct Arg Glu Trp Tyr Gln Ser Thr Ile Pro Gln Ser Pro Ser Pro Ala Pro 705 710 715 720			2160
gat gac cca gag gag gcc cgg cag ggt caa act gag aaa ttc cag ttt Asp Asp Pro Glu Glu Gly Arg Gln Gly Gln Thr Glu Lys Phe Gln Phe 725 730 735			2208
gaa cta act tta gag gaa gat ggt gag tca gac acg gaa aag gac agt Glu Leu Thr Leu Glu Glu Asp Gly Glu Ser Asp Thr Glu Lys Asp Ser 740 745 750			2256
ggc agt caa gtg gaa gaa gac act agc tgc agt gac tcc aag act ctt Gly Ser Gln Val Glu Glu Asp Thr Ser Cys Ser Asp Ser Lys Thr Leu 755 760 765			2304
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Cys Thr Gln Asp Ser Glu Ser Thr Glu Ile Pro Leu Asp Glu Gln Val	
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Glu Glu Glu Ala Val Gly Glu Glu Glu Ser Gln Pro Glu Ala Cys	
785 790 795 800	
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Val Ile Asp Asp Arg Ser Pro Asp Thr Thr Gly Ile Leu Gln Ser Thr	
805 810 815	
gta ccg cgg gcc cgg gat cca ccg gtc gcc acc atg gtg agc aag ggc	2496
Val Pro Arg Ala Arg Asp Pro Pro Val Ala Thr Met Val Ser Lys Gly	
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Glu Glu Leu Phe Thr Gly Val Val Pro Ile Leu Val Glu Leu Asp Gly	
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Asp Val Asn Gly His Lys Phe Ser Val Ser Gly Glu Gly Glu Gly Asp	
850 855 860	
gcc acc tac ggc aag ctg acc ctg aag ttc atc tgc acc acc ggc aag	2640
Ala Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile Cys Thr Thr Gly Lys	
865 870 875 880	
ctg ccc gtg ccc tgg ccc acc ctc gtg acc acc ctg acc tac ggc gtg	2688
Leu Pro Val Pro Trp Pro Thr Leu Val Thr Thr Leu Thr Tyr Gly Val	
885 890 895	
cag tgc ttc agc cgc tac ccc gac cac atg aag cag cac gac ttc ttc	2736
Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys Gln His Asp Phe Phe	
900 905 910	
aag tcc gcc atg ccc gaa ggc tac gtc cag gag cgc acc atc ttc ttc	2784
Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu Arg Thr Ile Phe Phe	
915 920 925	
aag gac gac ggc aac tac aag acc cgc gcc gag gtg aag ttc gag ggc	2832
Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu Val Lys Phe Glu Gly	
930 935 940	
gac acc ctg gtg aac cgc atc gag ctg aag ggc atc gac ttc aag gag	2880
Asp Thr Leu Val Asn Arg Ile Glu Leu Lys Gly Ile Asp Phe Lys Glu	
945 950 955 960	
gac ggc aac atc ctg ggg cac aag ctg gag tac aac tac aac agc cac	2928
Asp Gly Asn Ile Leu Gly His Lys Leu Glu Tyr Asn Tyr Asn Ser His	
965 970 975	
aac gtc tat atc atg gcc gac aag cag aag aac ggc atc aag gtg aac	2976
Asn Val Tyr Ile Met Ala Asp Lys Gln Lys Asn Gly Ile Lys Val Asn	
980 985 990	
ttc aag atc cgc cac aac atc gag gac ggc agc gtg cag ctc gcc gac	3024
Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser Val Gln Leu Ala Asp	
995 1000 1005	

cac tac cag cag aac acc ccc atc ggc gac ggc ccc gtg ctg ctg ccc 3072  
 His Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly Pro Val Leu Leu Pro  
 1010 1015 1020  
  
 gac aac cac tac ctg agc acc cag tcc gcc ctg agc aaa gac ccc aac 3120  
 Asp Asn His Tyr Leu Ser Thr Gln Ser Ala Leu Ser Lys Asp Pro Asn  
 1025 1030 1035 1040  
  
 gag aag cgc gat cac atg gtc ctg ctg gag ttc gtg acc gcc gcc ggg 3168  
 Glu Lys Arg Asp His Met Val Leu Leu Glu Phe Val Thr Ala Ala Gly  
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 Arg Leu Leu His Pro His His His Leu Pro Pro Pro Pro Pro Ser  
 50 55 60  
 Pro Gln Pro Gln Pro Gln Cys Pro Leu Gln Pro Pro Pro Pro Pro  
 65 70 75 80  
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 Ser Ser Gly Ala Thr Gly Arg Val Arg His Arg Gly Tyr Ser Asp Thr  
 100 105 110  
 Glu Arg Tyr Leu Tyr Cys Arg Ala Met Asp Arg Thr Ser Tyr Ala Val  
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 Glu Thr Gly His Arg Pro Gly Leu Lys Lys Ser Arg Met Ser Trp Pro  
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 Ser Ser Phe Gln Gly Leu Arg Arg Phe Asp Val Asp Asn Gly Thr Ser  
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 Ala Gly Arg Ser Pro Leu Asp Pro Met Thr Ser Pro Gly Ser Gly Leu  
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 Ile Leu Gln Ala Asn Phe Val His Ser Gln Arg Arg Glu Ser Phe Leu  
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 Tyr Arg Ser Asp Ser Asp Tyr Asp Leu Ser Pro Lys Ser Met Ser Arg  
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 Ala Ala Leu Thr Asn Leu Gln Asp Arg Ala Pro Ser Lys Arg Ser Pro  
 245 250 255  
 Met Cys Asn Gln Pro Ser Ile Asn Lys Ala Thr Ile Thr Glu Glu Ala  
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 275 280 285

Asp Gln Leu Glu Thr Leu Gln Thr Arg His Ser Val Ser Glu Met Ala  
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 Ser Asn Lys Phe Lys Arg Met Leu Asn Arg Glu Leu Thr His Leu Ser  
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 385 390 395 400  
 Val Asn Lys Trp Gly Leu His Val Phe Arg Ile Ala Glu Leu Ser Gly  
 405 410 415  
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 Ile His Ala Ala Asp Val Val Gln Ser Thr His Val Leu Leu Ser Thr  
 465 470 475 480  
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 515 520 525  
 Ser Val Leu Glu Asn His His Leu Ala Val Gly Phe Lys Leu Leu Gln  
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 Glu Glu Asn Cys Asp Ile Phe Gln Asn Leu Thr Lys Lys Gln Arg Gln  
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 Ser Leu Arg Lys Met Val Ile Asp Ile Val Leu Ala Thr Asp Met Ser  
 565 570 575  
 Lys His Met Asn Leu Leu Ala Asp Leu Lys Thr Met Val Glu Thr Lys  
 580 585 590  
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 595 600 605  
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 Glu Phe Phe Arg Gln Gly Asp Arg Glu Arg Glu Arg Gly Met Glu Ile  
 645 650 655  
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 660 665 670  
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 675 680 685  
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 Gly Ser Gln Val Glu Glu Asp Thr Ser Cys Ser Asp Ser Lys Thr Leu

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Cys Thr Gln Asp Ser Glu Ser Thr Glu Ile Pro Leu Asp Glu Gln Val
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Val Ile Asp Asp Arg Ser Pro Asp Thr Thr Gly Ile Leu Gln Ser Thr
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Val Pro Arg Ala Arg Asp Pro Pro Val Ala Thr Met Val Ser Lys Gly
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Glu Glu Leu Phe Thr Gly Val Val Pro Ile Leu Val Glu Leu Asp Gly
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Asp Val Asn Gly His Lys Phe Ser Val Ser Gly Glu Gly Glu Gly Asp
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Ala Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile Cys Thr Thr Gly Lys
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Leu Pro Val Pro Trp Pro Thr Leu Val Thr Thr Leu Thr Tyr Gly Val
      885      890      895
Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys Gln His Asp Phe Phe
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Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu Arg Thr Ile Phe Phe
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Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu Val Lys Phe Glu Gly
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Asp Thr Leu Val Asn Arg Ile Glu Leu Lys Gly Ile Asp Phe Lys Glu
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Asp Gly Asn Ile Leu Gly His Lys Leu Glu Tyr Asn Tyr Asn Ser His
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Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser Val Gln Leu Ala Asp
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aat ccg cat tgt cca aac ccg tgg ctg aac gaa gac ctt gtg aaa tcc      96
Asn Pro His Cys Pro Asn Pro Trp Leu Asn Glu Asp Leu Val Lys Ser
      20      25      30

ttg cga gaa aac ctg ttg cag cat gag aag tcc aag aca gcg agg aaa      144

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Ser Val Ser Pro Lys Leu Ser Pro Val Ile Ser Pro Arg Asn Ser Pro	
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agg ctt ctg cgc aga atg ctt ctc agc agc aac atc ccc aaa cag cgg	240
Arg Leu Leu Arg Arg Met Leu Leu Ser Ser Asn Ile Pro Lys Gln Arg	
65 70 75 80	
cgt ttc acg gtg gca cat aca tgt ttt gat gtg gac aat ggc aca tct	288
Arg Phe Thr Val Ala His Thr Cys Phe Asp Val Asp Asn Gly Thr Ser	
85 90 95	
gcg gga cgg agt ccc ttg gat ccc atg acc agc cca gga tcc ggg cta	336
Ala Gly Arg Ser Pro Leu Asp Pro Met Thr Ser Pro Gly Ser Gly Leu	
100 105 110	
att ctc caa gca aat ttt gtc cac agt caa cga cgg gag tcc ttc ctg	384
Ile Leu Gln Ala Asn Phe Val His Ser Gln Arg Arg Glu Ser Phe Leu	
115 120 125	
tat cga tcc gac agc gat tat gac ctc tct cca aag tct atg tcc cgg	432
Tyr Arg Ser Asp Ser Asp Tyr Asp Leu Ser Pro Lys Ser Met Ser Arg	
130 135 140	
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Asn Ser Ser Ile Ala Ser Asp Ile His Gly Asp Asp Leu Ile Val Thr	
145 150 155 160	
cca ttt gct cag gtc ttg gcc agt ctg cga act gta cga aac aac ttt	528
Pro Phe Ala Gln Val Leu Ala Ser Leu Arg Thr Val Arg Asn Asn Phe	
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gct gca tta act aat ttg caa gat cga gca cct agc aaa aga tca ccc	576
Ala Ala Leu Thr Asn Leu Gln Asp Arg Ala Pro Ser Lys Arg Ser Pro	
180 185 190	
atg tgc aac caa cca tcc atc aac aaa gcc acc ata aca gag gag gcc	624
Met Cys Asn Gln Pro Ser Ile Asn Lys Ala Thr Ile Thr Glu Glu Ala	
195 200 205	
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Tyr Gln Lys Leu Ala Ser Glu Thr Leu Glu Glu Leu Asp Trp Cys Leu	
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Asp Gln Leu Glu Thr Leu Gln Thr Arg His Ser Val Ser Glu Met Ala	
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gaa atg agt cgg tct gga aat caa gtg tca gag ttt ata tca aac aca	816
Glu Met Ser Arg Ser Gly Asn Gln Val Ser Glu Phe Ile Ser Asn Thr	
260 265 270	

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Leu Val His Pro Asp Ala Gln Asp Ile Leu Asp Thr Leu Glu Asp Asn	
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Cys Thr Gln Asp Ser Glu Ser Thr Glu Ile Pro Leu Asp Glu Gln Val	
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 Ser Val Ser Pro Lys Leu Ser Pro Val Ile Ser Pro Arg Asn Ser Pro  
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 Ala Gly Arg Ser Pro Leu Asp Pro Met Thr Ser Pro Gly Ser Gly Leu  
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 Ile Leu Gln Ala Asn Phe Val His Ser Gln Arg Arg Glu Ser Phe Leu  
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 Tyr Arg Ser Asp Ser Asp Tyr Asp Leu Ser Pro Lys Ser Met Ser Arg  
 130 135 140  
 Asn Ser Ser Ile Ala Ser Asp Ile His Gly Asp Asp Leu Ile Val Thr  
 145 150 155 160  
 Pro Phe Ala Gln Val Leu Ala Ser Leu Arg Thr Val Arg Asn Asn Phe  
 165 170 175  
 Ala Ala Leu Thr Asn Leu Gln Asp Arg Ala Pro Ser Lys Arg Ser Pro  
 180 185 190  
 Met Cys Asn Gln Pro Ser Ile Asn Lys Ala Thr Ile Thr Glu Glu Ala  
 195 200 205  
 Tyr Gln Lys Leu Ala Ser Glu Thr Leu Glu Glu Leu Asp Trp Cys Leu  
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 Asp Gln Leu Glu Thr Leu Gln Thr Arg His Ser Val Ser Glu Met Ala  
 225 230 235 240  
 Ser Asn Lys Phe Lys Arg Met Leu Asn Arg Glu Leu Thr His Leu Ser  
 245 250 255  
 Glu Met Ser Arg Ser Gly Asn Gln Val Ser Glu Phe Ile Ser Asn Thr  
 260 265 270  
 Phe Leu Asp Lys Gln His Glu Val Glu Ile Pro Ser Pro Thr Gln Lys  
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 Glu Lys Glu Lys Lys Lys Arg Pro Met Ser Gln Ile Ser Gly Val Lys  
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 Lys Leu Met His Ser Ser Ser Leu Thr Asn Ser Ser Ile Pro Arg Phe  
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 Gly Val Lys Thr Glu Gln Glu Asp Val Leu Ala Lys Glu Leu Glu Asp  
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Met	Thr	Leu	Glu	Asp	His	Tyr	His	Ala	Asp	Val	Ala	Tyr	His	Asn	Asn				
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Pro	Ala	Leu	Glu	Ala	Val	Phe	Thr	Asp	Leu	Glu	Ile	Leu	Ala	Ala	Ile				
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Phe	Ala	Ser	Ala	Ile	His	Asp	Val	Asp	His	Pro	Gly	Val	Ser	Asn	Gln				
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Asp	Asp	Pro	Glu	Gly	Arg	Gln	Gly	Gln	Thr	Glu	Lys	Phe	Gln	Phe					
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Glu	Leu	Thr	Leu	Glu	Glu	Asp	Gly	Glu	Ser	Asp	Thr	Glu	Lys	Asp	Ser				
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Cys	Thr	Gln	Asp	Ser	Glu	Ser	Thr	Glu	Ile	Pro	Leu	Asp	Glu	Gln	Val				
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Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys Gln His Asp Phe Phe  
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 Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu Arg Thr Ile Phe Phe  
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 Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu Val Lys Phe Glu Gly  
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 Asn Val Tyr Ile Met Ala Asp Lys Gln Lys Asn Gly Ile Lys Val Asn  
 915 920 925  
 Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser Val Gln Leu Ala Asp  
 930 935 940  
 His Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly Pro Val Leu Leu Pro  
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 Asp Asn His Tyr Leu Ser Thr Gln Ser Ala Leu Ser Lys Asp Pro Asn  
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 Trp Leu Asp Asp His Trp Asp Phe Thr Phe Ser Tyr Phe Val Arg Lys  
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 Ile Pro Val Cys Lys Glu Gly Ile Arg Gly His Thr Glu Ser Cys Ser  
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 Cys Pro Leu Gln Gln Ser Pro Arg Ala Asp Asn Ser Val Pro Gly Thr  
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 Pro Thr Arg Lys Ile Ser Ala Ser Glu Phe Asp Arg Pro Leu Arg Pro

22

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Thr Lys Pro Trp Pro Ile Gln Gln Arg Ile Ala Glu Leu Val Ala Thr	
770 775 780	
gaa ttt ttt gat caa gga gac aga gag aga aaa gaa ctc aac ata gaa	2400
Glu Phe Phe Asp Gln Gly Asp Arg Glu Arg Lys Glu Leu Asn Ile Glu	
785 790 795 800	
ccc act gat cta atg aac agg gag aag aaa aac aaa atc cca agt atg	2448
Pro Thr Asp Leu Met Asn Arg Glu Lys Lys Asn Lys Ile Pro Ser Met	
805 810 815	

caa gtt ggg ttc ata gat gcc atc tgc ttg caa ctg tat gag gcc ctg	2496
Gln Val Gly Phe Ile Asp Ala Ile Cys Leu Gln Leu Tyr Glu Ala Leu	
820 825 830	
acc cac gtg tca gag gac tgt ttc cct ttg cta gat ggc tgc aga aag	2544
Thr His Val Ser Glu Asp Cys Phe Pro Leu Leu Asp Gly Cys Arg Lys	
835 840 845	
aac agg cag aaa tgg cag gcc ctt gca gaa cag cag gag aag atg ctg	2592
Asn Arg Gln Lys Trp Gln Ala Leu Ala Glu Gln Gln Glu Lys Met Leu	
850 855 860	
att aat ggg gaa agc ggc cag gcc aag cgg aac tgg gta ccg cgg gcc	2640
Ile Asn Gly Glu Ser Gly Gln Ala Lys Arg Asn Trp Val Pro Arg Ala	
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cgg gat cca ccg gtc gcc acc atg gtg agc aag ggc gag gag ctg ttc	2688
Arg Asp Pro Pro Val Ala Thr Met Val Ser Lys Gly Glu Glu Leu Phe	
885 890 895	
acc ggg gtg gtg ccc atc ctg gtc gag ctg gac ggc gac gta aac ggc	2736
Thr Gly Val Val Pro Ile Leu Val Glu Leu Asp Gly Asp Val Asn Gly	
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cac aag ttc agc gtg tcc ggc gag ggc gag ggc gat gcc acc tac ggc	2784
His Lys Phe Ser Val Ser Gly Glu Gly Glu Gly Asp Ala Thr Tyr Gly	
915 920 925	
aag ctg acc ctg aag ttc atc tgc acc acc ggc aag ctg ccc gtg ccc	2832
Lys Leu Thr Leu Lys Phe Ile Cys Thr Thr Gly Lys Leu Pro Val Pro	
930 935 940	
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Trp Pro Thr Leu Val Thr Thr Leu Thr Tyr Gly Val Gln Cys Phe Ser	
945 950 955 960	
cgc tac ccc gac cac atg aag cag cac gac ttc ttc aag tcc gcc atg	2928
Arg Tyr Pro Asp His Met Lys Gln His Asp Phe Phe Lys Ser Ala Met	
965 970 975	
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Pro Glu Gly Tyr Val Gln Glu Arg Thr Ile Phe Phe Lys Asp Asp Gly	
980 985 990	
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Asn Tyr Lys Thr Arg Ala Glu Val Lys Phe Glu Gly Asp Thr Leu Val	
995 1000 1005	
aac cgc atc gag ctg aag ggc atc gac ttc aag gag gac ggc aac atc	3072
Asn Arg Ile Glu Leu Lys Gly Ile Asp Phe Lys Glu Asp Gly Asn Ile	
1010 1015 1020	
ctg ggg cac aag ctg gag tac aac tac aac agc cac aac gtc tat atc	3120
Leu Gly His Lys Leu Glu Tyr Asn Tyr Asn Ser His Asn Val Tyr Ile	
1025 1030 1035 1040	
atg gcc gac aag cag aag aac ggc atc aag gtg aac ttc aag atc cgc	3168
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<213> Aegvorea victoria and human
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Trp	Leu	Asp	Asp	His	Trp	Asp	Phe	Thr	Phe	Ser	Tyr	Phe	Val	Arg	Lys		
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Ala	Thr	Arg	Glu	Met	Val	Asn	Ala	Trp	Phe	Ala	Glu	Arg	Val	His	Thr		
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Ile	Pro	Val	Cys	Lys	Glu	Gly	Ile	Arg	Gly	His	Thr	Glu	Ser	Cys	Ser		
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Cys	Pro	Leu	Gln	Gln	Ser	Pro	Arg	Ala	Asp	Asn	Ser	Val	Pro	Gly	Thr		
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Pro	Thr	Arg	Lys	Ile	Ser	Ala	Ser	Glu	Phe	Asp	Arg	Pro	Leu	Arg	Pro		
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Ile	Val	Val	Lys	Asp	Ser	Glu	Gly	Thr	Val	Ser	Phe	Leu	Ser	Asp	Ser		
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Glu	Lys	Lys	Glu	Gln	Met	Pro	Leu	Thr	Pro	Pro	Arg	Phe	Asp	His	Asp		
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Glu	Gly	Asp	Gln	Cys	Ser	Arg	Leu	Leu	Glu	Leu	Val	Lys	Asp	Ile	Ser		
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Ser	His	Leu	Asp	Val	Thr	Ala	Leu	Cys	His	Lys	Ile	Phe	Leu	His	Ile		
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His	Gly	Leu	Ile	Ser	Ala	Asp	Arg	Tyr	Ser	Leu	Phe	Leu	Val	Cys	Glu		
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Asp	Ser	Ser	Asn	Asp	Lys	Phe	Leu	Ile	Ser	Arg	Leu	Phe	Asp	Val	Ala		
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Glu	Gly	Ser	Thr	Leu	Glu	Glu	Val	Ser	Asn	Asn	Cys	Ile	Arg	Leu	Glu		
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Trp	Asn	Lys	Gly	Ile	Val	Gly	His	Val	Ala	Ala	Leu	Gly	Glu	Pro	Leu		
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 Gln Ile Thr Gly Tyr Lys Thr Gln Ser Ile Leu Cys Met Pro Ile Lys  
 260 265 270  
 Asn His Arg Glu Glu Val Val Gly Val Ala Gln Ala Ile Asn Lys Lys  
 275 280 285  
 Ser Gly Asn Gly Gly Thr Phe Thr Glu Lys Asp Glu Lys Asp Phe Ala  
 290 295 300  
 Ala Tyr Leu Ala Phe Cys Gly Ile Val Leu His Asn Ala Gln Leu Tyr  
 305 310 315 320  
 Glu Thr Ser Leu Leu Glu Asn Lys Arg Asn Gln Val Leu Leu Asp Leu  
 325 330 335  
 Ala Ser Leu Ile Phe Glu Glu Gln Gln Ser Leu Glu Val Ile Leu Lys  
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 Lys Ile Ala Ala Thr Ile Ile Ser Phe Met Gln Val Gln Lys Cys Thr  
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 Ile Phe Ile Val Asp Glu Asp Cys Ser Asp Ser Phe Ser Ser Val Phe  
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 His Met Glu Cys Glu Glu Leu Glu Lys Ser Ser Asp Thr Leu Thr Arg  
 385 390 395 400  
 Glu His Asp Ala Asn Lys Ile Asn Tyr Met Tyr Ala Gln Tyr Val Lys  
 405 410 415  
 Asn Thr Met Glu Pro Leu Asn Ile Pro Asp Val Ser Lys Asp Lys Arg  
 420 425 430  
 Phe Pro Trp Thr Thr Glu Asn Thr Gly Asn Val Asn Gln Gln Cys Ile  
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 Arg Ser Leu Leu Cys Thr Pro Ile Lys Asn Gly Lys Lys Asn Lys Val  
 450 455 460  
 Ile Gly Val Cys Gln Leu Val Asn Lys Met Glu Glu Asn Thr Gly Lys  
 465 470 475 480  
 Val Lys Pro Phe Asn Arg Asn Asp Glu Gln Phe Leu Glu Ala Phe Val  
 485 490 495  
 Ile Phe Cys Gly Leu Gly Ile Gln Asn Thr Gln Met Tyr Glu Ala Val  
 500 505 510  
 Glu Arg Ala Met Ala Lys Gln Met Val Thr Leu Glu Val Leu Ser Tyr  
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 His Ala Ser Ala Ala Glu Glu Thr Arg Glu Leu Gln Ser Leu Ala  
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 Phe Ser Asp Phe Glu Leu Ser Asp Leu Glu Thr Ala Leu Cys Thr Ile  
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 Arg Met Phe Thr Asp Leu Asn Leu Val Gln Asn Phe Gln Met Lys His  
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 Glu Val Leu Cys Arg Trp Ile Leu Ser Val Lys Lys Asn Tyr Arg Lys  
 595 600 605  
 Asn Val Ala Tyr His Asn Trp Arg His Ala Phe Asn Thr Ala Gln Cys  
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 Leu Glu Ile Leu Ala Leu Leu Ile Ala Ala Leu Ser His Asp Leu Asp  
 645 650 655  
 His Arg Gly Val Asn Asn Ser Tyr Ile Gln Arg Ser Glu His Pro Leu  
 660 665 670  
 Ala Gln Leu Tyr Cys His Ser Ile Met Glu His His His Phe Asp Gln  
 675 680 685  
 Cys Leu Met Ile Leu Asn Ser Pro Gly Asn Gln Ile Leu Ser Gly Leu  
 690 695 700  
 Ser Ile Glu Glu Tyr Lys Thr Thr Leu Lys Ile Ile Lys Gln Ala Ile

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Glu	Leu	Ile	Arg	Lys	Asn	Gln	Phe	Asn	Glu	Glu	Asp	Pro	His	Gln	Lys				
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Glu	Leu	Phe	Leu	Ala	Met	Leu	Met	Thr	Ala	Cys	Asp	Leu	Ser	Ala	Ile				
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Thr	Lys	Pro	Trp	Pro	Ile	Gln	Gln	Arg	Ile	Ala	Glu	Leu	Val	Ala	Thr				
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Glu	Phe	Phe	Asp	Gln	Gly	Asp	Arg	Glu	Arg	Lys	Glu	Leu	Asn	Ile	Glu				
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Gln	Val	Gly	Phe	Ile	Asp	Ala	Ile	Cys	Leu	Gln	Leu	Tyr	Glu	Ala	Leu				
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Thr	His	Val	Ser	Glu	Asp	Cys	Phe	Pro	Leu	Leu	Asp	Gly	Cys	Arg	Lys				
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Asn	Arg	Gln	Lys	Trp	Gln	Ala	Leu	Ala	Glu	Gln	Glu	Lys	Met	Leu					
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Thr	Gly	Val	Val	Pro	Ile	Leu	Val	Glu	Leu	Asp	Gly	Asp	Val	Asn	Gly				
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His	Lys	Phe	Ser	Val	Ser	Gly	Glu	Gly	Glu	Gly	Asp	Ala	Thr	Tyr	Gly				
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Lys	Leu	Thr	Leu	Lys	Phe	Ile	Cys	Thr	Thr	Gly	Lys	Leu	Pro	Val	Pro				
			930			935					940								
Trp	Pro	Thr	Leu	Val	Thr	Thr	Leu	Thr	Tyr	Gly	Val	Gln	Cys	Phe	Ser				
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Arg	Tyr	Pro	Asp	His	Met	Lys	Gln	His	Asp	Phe	Phe	Lys	Ser	Ala	Met				
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Pro	Glu	Gly	Tyr	Val	Gln	Glu	Arg	Thr	Ile	Phe	Phe	Lys	Asp	Asp	Gly				
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Asn	Tyr	Lys	Thr	Arg	Ala	Glu	Val	Lys	Phe	Glu	Gly	Asp	Thr	Leu	Val				
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Met Lys Glu Arg Leu Gly Thr Gly Gly Phe Gly Asn Val Ile Arg Trp	
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cac aat cag gaa aca ggt gag cag att gcc atc aag cag tgc cgg cag	144
His Asn Gln Glu Thr Gly Glu Gln Ile Ala Ile Lys Gln Cys Arg Gln	
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gag ctc agc ccc cgg aac cga gag cgg tgg tgc ctg gag atc cag atc	192
Glu Leu Ser Pro Arg Asn Arg Glu Arg Trp Cys Leu Glu Ile Gln Ile	
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Met Arg Arg Leu Thr His Pro Asn Val Val Ala Ala Arg Asp Val Pro	
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gag ggg atg cag aac ttg gcg ccc aat gac ctg ccc ctg ctg gcc atg	288
Glu Gly Met Gln Asn Leu Ala Pro Asn Asp Leu Pro Leu Leu Ala Met	
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Glu Tyr Cys Gln Gly Gly Asp Leu Arg Lys Tyr Leu Asn Gln Phe Glu	
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aac tgc tgt ggt ctg cgg gaa ggt gcc atc ctc acc ttg ctg agt gac	384
Asn Cys Cys Gly Leu Arg Glu Gly Ala Ile Leu Thr Leu Leu Ser Asp	
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Ile Ala Ser Ala Leu Arg Tyr Leu His Glu Asn Arg Ile Ile His Arg	
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Asp Leu Lys Pro Glu Asn Ile Val Leu Gln Gln Gly Glu Gln Arg Leu	
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Ile His Lys Ile Ile Asp Leu Gly Tyr Ala Lys Glu Leu Asp Gln Gly	
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Ser Leu Cys Thr Ser Phe Val Gly Thr Leu Gln Tyr Leu Ala Pro Glu	
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Leu Leu Glu Gln Gln Lys Tyr Thr Val Thr Val Asp Tyr Trp Ser Phe	
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Gly Thr Leu Ala Phe Glu Cys Ile Thr Gly Phe Arg Pro Phe Leu Pro	

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ctg gag aag tgg ctg caa ctg atg ctg atg tgg cac ccc cga cag agg Leu Glu Lys Trp Leu Gln Leu Met Leu Met Trp His Pro Arg Gln Arg 275 280 285			864
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gac atc tta aac tta aag ctg gtt cat atc ttg aac atg gtc acg ggc Asp Ile Leu Asn Leu Lys Leu Val His Ile Leu Asn Met Val Thr Gly 305 310 315 320			960
acc atc cac acc tac cct gtg aca gag gat gag agt ctg cag agc ttg Thr Ile His Thr Tyr Pro Val Thr Glu Asp Glu Ser Leu Gln Ser Leu 325 330 335			1008
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Tyr Ser Glu Gln Thr Glu Phe Gly Ile Thr Ser Asp Lys Leu Leu Leu	
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cag cac gac ttc ttc aag tcc gcc atg ccc gaa ggc tac gtc cag gag Gln His Asp Phe Phe Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu 850 855 860	2592
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 gtg cag ctc gcc gac cac tac cag cag aac acc ccc atc ggc gac ggc 2880  
 Val Gln Leu Ala Asp His Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly  
 945 950 955 960  
 ccc gtg ctg ctg ccc gac aac cac tac ctg agc acc cag tcc gcc ctg 2928  
 Pro Val Leu Leu Pro Asp Asn His Tyr Leu Ser Thr Gln Ser Ala Leu  
 965 970 975  
 agc aaa gac ccc aac gag aag cgc gat cac atg gtc ctg ctg gag ttc 2976  
 Ser Lys Asp Pro Asn Glu Lys Arg Asp His Met Val Leu Leu Glu Phe  
 980 985 990  
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 995 1000 1005

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&lt;211&gt; 1007

&lt;212&gt; PRT

&lt;213&gt; Aequorea victoria and human

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 His Asn Gln Glu Thr Gly Glu Gln Ile Ala Ile Lys Gln Cys Arg Gln  
 35 40 45  
 Glu Leu Ser Pro Arg Asn Arg Glu Arg Trp Cys Leu Glu Ile Gln Ile  
 50 55 60  
 Met Arg Arg Leu Thr His Pro Asn Val Val Ala Arg Asp Val Pro  
 65 70 75 80  
 Glu Gly Met Gln Asn Leu Ala Pro Asn Asp Leu Pro Leu Leu Ala Met  
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 Glu Tyr Cys Gln Gly Gly Asp Leu Arg Lys Tyr Leu Asn Gln Phe Glu  
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 Asn Cys Cys Gly Leu Arg Glu Gly Ala Ile Leu Thr Leu Leu Ser Asp  
 115 120 125  
 Ile Ala Ser Ala Leu Arg Tyr Leu His Glu Asn Arg Ile Ile His Arg  
 130 135 140  
 Asp Leu Lys Pro Glu Asn Ile Val Leu Gln Gln Gly Glu Gln Arg Leu  
 145 150 155 160  
 Ile His Lys Ile Ile Asp Leu Gly Tyr Ala Lys Glu Leu Asp Gln Gly  
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 Ser Leu Cys Thr Ser Phe Val Gly Thr Leu Gln Tyr Leu Ala Pro Glu  
 180 185 190  
 Leu Leu Glu Gln Gln Lys Tyr Thr Val Thr Val Asp Tyr Trp Ser Phe  
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 Gly Thr Leu Ala Phe Glu Cys Ile Thr Gly Phe Arg Pro Phe Leu Pro  
 210 215 220  
 Asn Trp Gln Pro Val Gln Trp His Ser Lys Val Arg Gln Lys Ser Glu  
 225 230 235 240  
 Val Asp Ile Val Val Ser Glu Asp Leu Asn Gly Thr Val Lys Phe Ser

245 250 255  
 Ser Ser Leu Pro Tyr Pro Asn Asn Leu Asn Ser Val Leu Ala Glu Arg  
 260 265 270  
 Leu Glu Lys Trp Leu Gln Leu Met Leu Met Trp His Pro Arg Gln Arg  
 275 280 285  
 Gly Thr Asp Pro Thr Tyr Gly Pro Asn Gly Cys Phe Lys Ala Leu Asp  
 290 295 300  
 Asp Ile Leu Asn Leu Lys Leu Val His Ile Leu Asn Met Val Thr Gly  
 305 310 315 320  
 Thr Ile His Thr Tyr Pro Val Thr Glu Asp Glu Ser Leu Gln Ser Leu  
 325 330 335  
 Lys Ala Arg Ile Gln Gln Asp Thr Gly Ile Pro Glu Glu Asp Gln Glu  
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 355 360 365  
 Gln Cys Ile Ser Asp Gly Lys Leu Asn Glu Gly His Thr Leu Asp Met  
 370 375 380  
 Asp Leu Val Phe Leu Phe Asp Asn Ser Lys Ile Thr Tyr Glu Thr Gln  
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 Pro Lys Arg Asn Leu Ala Phe Phe Gln Leu Arg Lys Val Trp Gly Gln  
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 Val Trp His Ser Ile Gln Thr Leu Lys Glu Asp Cys Asn Arg Leu Gln  
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 Gln Gly Gln Arg Ala Ala Met Met Asn Leu Leu Arg Asn Asn Ser Cys  
 450 455 460  
 Leu Ser Lys Met Lys Asn Ser Met Ala Ser Met Ser Gln Gln Leu Lys  
 465 470 475 480  
 Ala Lys Leu Asp Phe Phe Lys Thr Ser Ile Gln Ile Asp Leu Glu Lys  
 485 490 495  
 Tyr Ser Glu Gln Thr Glu Phe Gly Ile Thr Ser Asp Lys Leu Leu Leu  
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 Ala Trp Arg Glu Met Glu Gln Ala Val Glu Leu Cys Gly Arg Glu Asn  
 515 520 525  
 Glu Val Lys Leu Leu Val Glu Arg Met Met Ala Leu Gln Thr Asp Ile  
 530 535 540  
 Val Asp Leu Gln Arg Ser Pro Met Gly Arg Lys Gln Gly Gly Thr Leu  
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 Asp Asp Leu Glu Glu Gln Ala Arg Glu Leu Tyr Arg Arg Leu Arg Glu  
 565 570 575  
 Lys Pro Arg Asp Gln Arg Thr Glu Gly Asp Ser Gln Glu Met Val Arg  
 580 585 590  
 Leu Leu Leu Gln Ala Ile Gln Ser Phe Glu Lys Lys Val Arg Val Ile  
 595 600 605  
 Tyr Thr Gln Leu Ser Lys Thr Val Val Cys Lys Gln Lys Ala Leu Glu  
 610 615 620  
 Leu Leu Pro Lys Val Glu Glu Val Val Ser Leu Met Asn Glu Asp Glu  
 625 630 635 640  
 Lys Thr Val Val Arg Leu Gln Glu Lys Arg Gln Lys Glu Leu Trp Asn  
 645 650 655  
 Leu Leu Lys Ile Ala Cys Ser Lys Val Arg Gly Pro Val Ser Gly Ser  
 660 665 670  
 Pro Asp Ser Met Asn Ala Ser Arg Leu Ser Gln Pro Gly Gln Leu Met  
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 Ser Gln Pro Ser Thr Ala Ser Asn Ser Leu Pro Glu Pro Ala Lys Lys  
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<212> DNA
<213> Aegveora victoria and human
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Met	Asp	Glu	Leu	Phe	Pro	Leu	Ile	Phe	Pro	Ala	Glu	Pro	Ala	Gln	Ala
1				5					10					15	
tct	ggc	ccc	tat	gtg	gag	atc	att	gag	cag	ccc	aag	cag	cgg	ggc	atg
Ser	Gly	Pro	Tyr	Val	Glu	Ile	Ile	Glu	Gln	Pro	Lys	Gln	Arg	Gly	Met
			20					25					30		
cgc	ttc	cgc	tac	aag	tgc	gag	ggg	cgc	tcc	gcg	ggc	agc	atc	cca	ggc
Arg	Phe	Arg	Tyr	Lys	Cys	Glu	Gly	Arg	Ser	Ala	Gly	Ser	Ile	Pro	Gly
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48

96

144

gag agg agc aca gat acc acc aag acc cac ccc acc atc aag atc aat	192
Glu Arg Ser Thr Asp Thr Thr Lys Thr His Pro Thr Ile Lys Ile Asn	
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ggc tac aca gga cca ggg aca gtg cgc atc tcc ctg gtc acc aag gac	240
Gly Tyr Thr Gly Pro Gly Thr Val Arg Ile Ser Leu Val Thr Lys Asp	
65 70 75 80	
cct cct cac cgg cct cac ccc cac gag ctt gta gga aag gac tgc cgg	288
Pro Pro His Arg Pro His Pro His Glu Leu Val Gly Lys Asp Cys Arg	
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gat ggc ttc tat gag gct gag ctc tgc ccg gac cgc tgc atc cac agt	336
Asp Gly Phe Tyr Glu Ala Glu Leu Cys Pro Asp Arg Cys Ile His Ser	
100 105 110	
ttc cag aac ctg gga atc cag tgt gtg aag aag cgg gac ctg gag cag	384
Phe Gln Asn Leu Gly Ile Gln Cys Val Lys Lys Arg Asp Leu Glu Gln	
115 120 125	
gct atc agt cag cgc atc cag acc aac aac aac ccc ttc caa gtt cct	432
Ala Ile Ser Gln Arg Ile Gln Thr Asn Asn Asn Pro Phe Gln Val Pro	
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ata gaa gag cag cgt ggg gac tac gac ctg aat gct gtg cgg ctc tgc	480
Ile Glu Glu Gln Arg Gly Asp Tyr Asp Leu Asn Ala Val Arg Leu Cys	
145 150 155 160	
ttc cag gtg aca gtg cgg gac cca tca ggc agg ccc ctc cgc ctg ccg	528
Phe Gln Val Thr Val Arg Asp Pro Ser Gly Arg Pro Leu Arg Leu Pro	
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cct gtc ctt cct cat ccc atc ttt gac aat cgt gcc ccc aac act gcc	576
Pro Val Leu Pro His Pro Ile Phe Asp Asn Arg Ala Pro Asn Thr Ala	
180 185 190	
gag ctc aag atc tgc cga gtg aac cga aac tct ggc agc tgc ctc ggt	624
Glu Leu Lys Ile Cys Arg Val Asn Arg Asn Ser Gly Ser Cys Leu Gly	
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ggg gat gag atc ttc cta ctg tgt gac aag gtg cag aaa gag gac att	672
Gly Asp Glu Ile Phe Leu Leu Cys Asp Lys Val Gln Lys Glu Asp Ile	
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Glu Val Tyr Phe Thr Gly Pro Gly Trp Glu Ala Arg Gly Ser Phe Ser	
225 230 235 240	
caa gct gat gtg cac cga caa gtg gcc att gtg ttc cgg acc cct ccc	768
Gln Ala Asp Val His Arg Gln Val Ala Ile Val Phe Arg Thr Pro Pro	
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tac gca gac ccc agc ctg cag gct cct gtg cgt gtc tcc atg cag ctg	816
Tyr Ala Asp Pro Ser Leu Gln Ala Pro Val Arg Val Ser Met Gln Leu	
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Arg Arg Pro Ser Asp Arg Glu Leu Ser Glu Pro Met Glu Phe Gln Tyr	
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aca tat gag acc ttc aag agc atc atg aag aag agt cct ttc agc gga Thr Tyr Glu Thr Phe Lys Ser Ile Met Lys Lys Ser Pro Phe Ser Gly 305 310 315 320	960
ccc acc gac ccc cgg cct cca cct cga cgc att gct gtg cct tcc cgc Pro Thr Asp Pro Arg Pro Pro Pro Arg Arg Ile Ala Val Pro Ser Arg 325 330 335	1008
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cct tct ggg cag atc agc cag gcc tcg gcc ttg gcc ccg gcc cct ccc Pro Ser Gly Gln Ile Ser Gln Ala Ser Ala Leu Ala Pro Ala Pro Pro 370 375 380	1152
caa gtc ctg ccc cag gct cca gcc cct gcc cct gct cca gcc atg gta Gln Val Leu Pro Gln Ala Pro Ala Pro Ala Pro Ala Pro Ala Met Val 385 390 395 400	1200
tca gct ctg gcc cag gcc cca gcc cct gtc cca gtc cta gcc cca gcc Ser Ala Leu Ala Gln Ala Pro Ala Pro Val Pro Val Leu Ala Pro Gly 405 410 415	1248
cct cct cag gct gtg gcc cca cct gcc ccc aag ccc acc cag gct ggg Pro Pro Gln Ala Val Ala Pro Pro Ala Pro Lys Pro Thr Gln Ala Gly 420 425 430	1296
gaa gga acg ctg tca gag gcc ctg ctg cag ctg cag ttt gat gat gaa Glu Gly Thr Leu Ser Glu Ala Leu Leu Gln Leu Gln Phe Asp Asp Glu 435 440 445	1344
gac ctg ggg gcc ttg ctt ggc aac agc aca gac cca gct gtg ttc aca Asp Leu Gly Ala Leu Leu Gly Asn Ser Thr Asp Pro Ala Val Phe Thr 450 455 460	1392
gac ctg gca tcc gtc gac aac tcc gag ttt cag cag ctg ctg aac cag Asp Leu Ala Ser Val Asp Asn Ser Glu Phe Gln Gln Leu Leu Asn Gln 465 470 475 480	1440
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cct gag gct ata act cgc cta gtg aca ggg gcc cag agg ccc ccc gac Pro Glu Ala Ile Thr Arg Leu Val Thr Gly Ala Gln Arg Pro Pro Asp 500 505 510	1536
cca gct cct gct cca ctg ggg gcc ccg ggg ctc ccc aat ggc ctc ctt Pro Ala Pro Ala Pro Leu Gly Ala Pro Gly Leu Pro Asn Gly Leu Leu	1584

515	520	525	
tca gga gat gaa gac ttc tcc tcc att gcg gac atg gac ttc tca gcc Ser Gly Asp Glu Asp Phe Ser Ser Ile Ala Asp Met Asp Phe Ser Ala 530 535 540			1632
ctg ctg agt cag atc agc tcc aag ctt cga att ctg cag tcg acg gta Leu Leu Ser Gln Ile Ser Ser Lys Leu Arg Ile Leu Gln Ser Thr Val 545 550 555 560			1680
ccg cgg gcc cgg gat cca ccg gtc gcc acc atg gtg agc aag ggc gag Pro Arg Ala Arg Asp Pro Pro Val Ala Thr Met Val Ser Lys Gly Glu 565 570 575			1728
gag ctg ttc acc ggg gtg gtg ccc atc ctg gtc gag ctg gac ggc gac Glu Leu Phe Thr Gly Val Val Pro Ile Leu Val Glu Leu Asp Gly Asp 580 585 590			1776
gta aac ggc cac aag ttc agc gtg tcc ggc gag ggc gag ggc gat gcc Val Asn Gly His Lys Phe Ser Val Ser Gly Glu Gly Gly Asp Ala 595 600 605			1824
acc tac ggc aag ctg acc ctg aag ttc atc tgc acc acc ggc aag ctg Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile Cys Thr Thr Gly Lys Leu 610 615 620			1872
ccc gtg ccc tgg ccc acc ctc gtg acc acc ctg acc tac ggc gtg cag Pro Val Pro Trp Pro Thr Leu Val Thr Thr Leu Thr Tyr Gly Val Gln 625 630 635 640			1920
tgc ttc agc cgc tac ccc gac cac atg aag cag cac gac ttc ttc aag Cys Phe Ser Arg Tyr Pro Asp His Met Lys Gln His Asp Phe Phe Lys 645 650 655			1968
tcc gcc atg ccc gaa ggc tac gtc cag gag cgc acc atc ttc ttc aag Ser Ala Met Pro Glu Gly Tyr Val Gln Glu Arg Thr Ile Phe Phe Lys 660 665 670			2016
gac gac ggc aac tac aag acc cgc gcc gag gtg aag ttc gag ggc gac Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu Val Lys Phe Glu Gly Asp 675 680 685			2064
acc ctg gtg aac cgc atc gag ctg aag ggc atc gac ttc aag gag gac Thr Leu Val Asn Arg Ile Glu Leu Lys Gly Ile Asp Phe Lys Glu Asp 690 695 700			2112
ggc aac atc ctg ggg cac aag ctg gag tac aac tac aac agc cac aac Gly Asn Ile Leu Gly His Lys Leu Glu Tyr Asn Tyr Asn Ser His Asn 705 710 715 720			2160
gtc tat atc atg gcc gac aag cag aag aac ggc atc aag gtg aac ttc Val Tyr Ile Met Ala Asp Lys Gln Lys Asn Gly Ile Lys Val Asn Phe 725 730 735			2208
aag atc cgc cac aac atc gag gac ggc agc gtg cag ctc gcc gac cac Lys Ile Arg His Asn Ile Glu Asp Gly Ser Val Gln Leu Ala Asp His 740 745 750			2256
tac cag cag aac acc ccc atc ggc gac ggc ccc gtg ctg ctg ccc gac			2304

Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly Pro Val Leu Leu Pro Asp  
 755 760 765  
 aac cac tac ctg agc acc cag tcc gcc ctg agc aaa gac ccc aac gag 2352  
 Asn His Tyr Leu Ser Thr Gln Ser Ala Leu Ser Lys Asp Pro Asn Glu  
 770 775 780  
 aag cgc gat cac atg gtc ctg ctg gag ttc gtg acc gcc gcc ggg atc 2400  
 Lys Arg Asp His Met Val Leu Leu Glu Phe Val Thr Ala Ala Gly Ile  
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 Thr Leu Gly Met Asp Glu Leu Tyr Lys \*  
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 Arg Phe Arg Tyr Lys Cys Glu Gly Arg Ser Ala Gly Ser Ile Pro Gly  
 35 40 45  
 Glu Arg Ser Thr Asp Thr Thr Lys Thr His Pro Thr Ile Lys Ile Asn  
 50 55 60  
 Gly Tyr Thr Gly Pro Gly Thr Val Arg Ile Ser Leu Val Thr Lys Asp  
 65 70 75 80  
 Pro Pro His Arg Pro His Pro His Glu Leu Val Gly Lys Asp Cys Arg  
 85 90 95  
 Asp Gly Phe Tyr Glu Ala Glu Leu Cys Pro Asp Arg Cys Ile His Ser  
 100 105 110  
 Phe Gln Asn Leu Gly Ile Gln Cys Val Lys Lys Arg Asp Leu Glu Gln  
 115 120 125  
 Ala Ile Ser Gln Arg Ile Gln Thr Asn Asn Asn Pro Phe Gln Val Pro  
 130 135 140  
 Ile Glu Glu Gln Arg Gly Asp Tyr Asp Leu Asn Ala Val Arg Leu Cys  
 145 150 155 160  
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 165 170 175  
 Pro Val Leu Pro His Pro Ile Phe Asp Asn Arg Ala Pro Asn Thr Ala  
 180 185 190  
 Glu Leu Lys Ile Cys Arg Val Asn Arg Asn Ser Gly Ser Cys Leu Gly  
 195 200 205  
 Gly Asp Glu Ile Phe Leu Leu Cys Asp Lys Val Gln Lys Glu Asp Ile  
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 Glu Val Tyr Phe Thr Gly Pro Gly Trp Glu Ala Arg Gly Ser Phe Ser  
 225 230 235 240  
 Gln Ala Asp Val His Arg Gln Val Ala Ile Val Phe Arg Thr Pro Pro  
 245 250 255  
 Tyr Ala Asp Pro Ser Leu Gln Ala Pro Val Arg Val Ser Met Gln Leu  
 260 265 270  
 Arg Arg Pro Ser Asp Arg Glu Leu Ser Glu Pro Met Glu Phe Gln Tyr  
 275 280 285  
 Leu Pro Asp Thr Asp Asp Arg His Arg Ile Glu Glu Lys Arg Lys Arg

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 Ser Ser Leu Ser Thr Ile Asn Tyr Asp Glu Phe Pro Thr Met Val Phe  
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 Pro Ser Gly Gln Ile Ser Gln Ala Ser Ala Leu Ala Pro Ala Pro Pro  
 370 375 380  
 Gln Val Leu Pro Gln Ala Pro Ala Pro Ala Pro Ala Pro Ala Met Val  
 385 390 395 400  
 Ser Ala Leu Ala Gln Ala Pro Ala Pro Val Pro Val Leu Ala Pro Gly  
 405 410 415  
 Pro Pro Gln Ala Val Ala Pro Pro Ala Pro Lys Pro Thr Gln Ala Gly  
 420 425 430  
 Glu Gly Thr Leu Ser Glu Ala Leu Leu Gln Leu Gln Phe Asp Asp Glu  
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 450 455 460  
 Asp Leu Ala Ser Val Asp Asn Ser Glu Phe Gln Gln Leu Leu Asn Gln  
 465 470 475 480  
 Gly Ile Pro Val Ala Pro His Thr Thr Glu Pro Met Leu Met Glu Tyr  
 485 490 495  
 Pro Glu Ala Ile Thr Arg Leu Val Thr Gly Ala Gln Arg Pro Pro Asp  
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 Pro Ala Pro Ala Pro Leu Gly Ala Pro Gly Leu Pro Asn Gly Leu Leu  
 515 520 525  
 Ser Gly Asp Glu Asp Phe Ser Ser Ile Ala Asp Met Asp Phe Ser Ala  
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 565 570 575  
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 580 585 590  
 Val Asn Gly His Lys Phe Ser Val Ser Gly Glu Gly Glu Gly Asp Ala  
 595 600 605  
 Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile Cys Thr Thr Gly Lys Leu  
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 Pro Val Pro Trp Pro Thr Leu Val Thr Thr Leu Thr Tyr Gly Val Gln  
 625 630 635 640  
 Cys Phe Ser Arg Tyr Pro Asp His Met Lys Gln His Asp Phe Phe Lys  
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 Ser Ala Met Pro Glu Gly Tyr Val Gln Glu Arg Thr Ile Phe Phe Lys  
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 Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu Val Lys Phe Glu Gly Asp  
 675 680 685  
 Thr Leu Val Asn Arg Ile Glu Leu Lys Gly Ile Asp Phe Lys Glu Asp  
 690 695 700  
 Gly Asn Ile Leu Gly His Lys Leu Glu Tyr Asn Tyr Asn Ser His Asn  
 705 710 715 720  
 Val Tyr Ile Met Ala Asp Lys Gln Lys Asn Gly Ile Lys Val Asn Phe  
 725 730 735  
 Lys Ile Arg His Asn Ile Glu Asp Gly Ser Val Gln Leu Ala Asp His  
 740 745 750  
 Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly Pro Val Leu Leu Pro Asp  
 755 760 765

Asn His Tyr Leu Ser Thr Gln Ser Ala Leu Ser Lys Asp Pro Asn Glu  
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 Lys Arg Asp His Met Val Leu Leu Glu Phe Val Thr Ala Ala Gly Ile  
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 Thr Leu Gly Met Asp Glu Leu Tyr Lys  
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 <213> *Aequorea victoria* and human

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 Val Glu Leu Asp Gly Asp Val Asn Gly His Lys Phe Ser Val Ser Gly  
 20 25 30  
 gag ggc gag ggc gat gcc acc tac ggc aag ctg acc ctg aag ttc atc 144  
 Glu Gly Glu Gly Asp Ala Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile  
 35 40 45  
 tgc acc acc ggc aag ctg ccc gtg ccc tgg ccc acc ctc gtg acc acc 192  
 Cys Thr Thr Gly Lys Leu Pro Val Pro Trp Pro Thr Leu Val Thr Thr  
 50 55 60  
 ctg acc tac ggc gtg cag tgc ttc agc cgc tac ccc gac cac atg aag 240  
 Leu Thr Tyr Gly Val Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys  
 65 70 75 80  
 cag cac gac ttc ttc aag tcc gcc atg ccc gaa ggc tac gtc cag gag 288  
 Gln His Asp Phe Phe Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu  
 85 90 95  
 cgc acc atc ttc ttc aag gac gac ggc aac tac aag acc cgc gcc gag 336  
 Arg Thr Ile Phe Phe Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu  
 100 105 110  
 gtg aag ttc gag ggc gac acc ctg gtg aac cgc atc gag ctg aag ggc 384  
 Val Lys Phe Glu Gly Asp Thr Leu Val Asn Arg Ile Glu Leu Lys Gly  
 115 120 125  
 atc gac ttc aag gag gac ggc aac atc ctg ggg cac aag ctg gag tac 432  
 Ile Asp Phe Lys Glu Asp Gly Asn Ile Leu Gly His Lys Leu Glu Tyr  
 130 135 140  
 aac tac aac agc cac aac gtc tat atc atg gcc gac aag cag aag aac 480  
 Asn Tyr Asn Ser His Asn Val Tyr Ile Met Ala Asp Lys Gln Lys Asn  
 145 150 155 160  
 ggc atc aag gtg aac ttc aag atc cgc cac aac atc gag gac ggc agc 528  
 Gly Ile Lys Val Asn Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser

gtg	cag	ctc	gcc	gac	cac	tac	cag	cag	aac	acc	ccc	atc	ggc	gac	ggc	576
Val	Gln	Leu	Ala	Asp	His	Tyr	Gln	Gln	Asn	Thr	Pro	Ile	Gly	Asp	Gly	
		180						185					190			
ccc	gtg	ctg	ctg	ccc	gac	aac	cac	tac	ctg	agc	acc	cag	tcc	gcc	ctg	624
Pro	Val	Leu	Leu	Pro	Asp	Asn	His	Tyr	Leu	Ser	Thr	Gln	Ser	Ala	Leu	
		195				200						205				
agc	aaa	gac	ccc	aac	gag	aag	cgc	gat	cac	atg	gtc	ctg	ctg	gag	ttc	672
Ser	Lys	Asp	Pro	Asn	Glu	Lys	Arg	Asp	His	Met	Val	Leu	Leu	Glu	Phe	
	210					215					220					
gtg	acc	gcc	gcc	ggg	atc	act	ctc	ggc	atg	gac	gag	ctg	tac	aag	tcc	720
Val	Thr	Ala	Ala	Gly	Ile	Thr	Leu	Gly	Met	Asp	Glu	Leu	Tyr	Lys	Ser	
225					230				235						240	
gga	ctc	aga	tct	cga	gct	caa	gct	tac	atg	agc	tgg	tca	cct	tcc	ctg	768
Gly	Leu	Arg	Ser	Arg	Ala	Gln	Ala	Tyr	Met	Ser	Trp	Ser	Pro	Ser	Leu	
				245					250					255		
aca	acg	cag	aca	tgt	ggg	gcc	tgg	gaa	atg	aaa	gag	cgc	ctt	ggg	aca	816
Thr	Thr	Gln	Thr	Cys	Gly	Ala	Trp	Glu	Met	Lys	Glu	Arg	Leu	Gly	Thr	
			260					265					270			
ggg	gga	ttt	gga	aat	gtc	atc	cga	tgg	cac	aat	cag	gaa	aca	ggg	gag	864
Gly	Gly	Phe	Gly	Asn	Val	Ile	Arg	Trp	His	Asn	Gln	Glu	Thr	Gly	Glu	
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cag	att	gcc	atc	aag	cag	tgc	cgg	cag	gag	ctc	agc	ccc	cgg	aac	cga	912
Gln	Ile	Ala	Ile	Lys	Gln	Cys	Arg	Gln	Glu	Leu	Ser	Pro	Arg	Asn	Arg	
	290					295					300					
gag	cgg	tgg	tgc	ctg	gag	atc	cag	atc	atg	aga	agg	ctg	acc	cac	ccc	960
Glu	Arg	Trp	Cys	Leu	Glu	Ile	Gln	Ile	Met	Arg	Arg	Leu	Thr	His	Pro	
305					310				315						320	
aat	gtg	gtg	gct	gcc	cga	gat	gtc	cct	gag	ggg	atg	cag	aac	ttg	gcg	1008
Asn	Val	Val	Ala	Ala	Arg	Asp	Val	Pro	Glu	Gly	Met	Gln	Asn	Leu	Ala	
			325						330					335		
ccc	aat	gac	ctg	ccc	ctg	ctg	gcc	atg	gag	tac	tgc	caa	gga	gga	gat	1056
Pro	Asn	Asp	Leu	Pro	Leu	Leu	Ala	Met	Glu	Tyr	Cys	Gln	Gly	Gly	Asp	
			340					345					350			
ctc	cgg	aag	tac	ctg	aac	cag	ttt	gag	aac	tgc	tgt	ggg	ctg	cgg	gaa	1104
Leu	Arg	Lys	Tyr	Leu	Asn	Gln	Phe	Glu	Asn	Cys	Cys	Gly	Leu	Arg	Glu	
			355				360					365				
ggg	gcc	atc	ctc	acc	ttg	ctg	agt	gac	att	gcc	tct	gcg	ctt	aga	tac	1152
Gly	Ala	Ile	Leu	Thr	Leu	Leu	Ser	Asp	Ile	Ala	Ser	Ala	Leu	Arg	Tyr	

Val Leu Gln Gln Gly Glu Gln Arg Leu Ile His Lys Ile Ile Asp Leu	
405 410 415	
gga tat gcc aag gag ctg gat cag ggc agt ctt tgc aca tca ttc gtg	1296
Gly Tyr Ala Lys Glu Leu Asp Gln Gly Ser Leu Cys Thr Ser Phe Val	
420 425 430	
ggg acc ctg cag tac ctg gcc cca gag cta ctg gag cag cag aag tac	1344
Gly Thr Leu Gln Tyr Leu Ala Pro Glu Leu Leu Glu Gln Gln Lys Tyr	
435 440 445	
aca gtg acc gtc gac tac tgg agc ttc ggc acc ctg gcc ttt gag tgc	1392
Thr Val Thr Val Asp Tyr Trp Ser Phe Gly Thr Leu Ala Phe Glu Cys	
450 455 460	
atc acg ggc ttc cgg ccc ttc ctc ccc aac tgg cag ccc gtg cag tgg	1440
Ile Thr Gly Phe Arg Pro Phe Leu Pro Asn Trp Gln Pro Val Gln Trp	
465 470 475 480	
cat tca aaa gtg cgg cag aag agt gag gtg gac att gtt gtt agc gaa	1488
His Ser Lys Val Arg Gln Lys Ser Glu Val Asp Ile Val Val Ser Glu	
485 490 495	
gac ttg aat gga acg gtg aag ttt tca agc tct tta ccc tac ccc aat	1536
Asp Leu Asn Gly Thr Val Lys Phe Ser Ser Ser Leu Pro Tyr Pro Asn	
500 505 510	
aat ctt aac agt gtc ctg gct gag cga ctg gag aag tgg ctg caa ctg	1584
Asn Leu Asn Ser Val Leu Ala Glu Arg Leu Glu Lys Trp Leu Gln Leu	
515 520 525	
atg ctg atg tgg cac ccc cga cag agg ggc acg gat ccc acg tat ggg	1632
Met Leu Met Trp His Pro Arg Gln Arg Gly Thr Asp Pro Thr Tyr Gly	
530 535 540	
ccc aat ggc tgc ttc aag gcc ctg gat gac atc tta aac tta aag ctg	1680
Pro Asn Gly Cys Phe Lys Ala Leu Asp Asp Ile Leu Asn Leu Lys Leu	
545 550 555 560	
gtt cat atc ttg aac atg gtc acg ggc acc atc cac acc tac cct gtg	1728
Val His Ile Leu Asn Met Val Thr Gly Thr Ile His Thr Tyr Pro Val	
565 570 575	
aca gag gat gag agt ctg cag agc ttg aag gcc aga atc caa cag gac	1776
Thr Glu Asp Glu Ser Leu Gln Ser Leu Lys Ala Arg Ile Gln Gln Asp	
580 585 590	
acg ggc atc cca gag gag gac cag gag ctg ctg cag gaa gcg ggc ctg	1824
Thr Gly Ile Pro Glu Glu Asp Gln Glu Leu Leu Gln Glu Ala Gly Leu	
595 600 605	
gcg ttg atc ccc gat aag cct gcc act cag tgt att tca gac ggc aag	1872
Ala Leu Ile Pro Asp Lys Pro Ala Thr Gln Cys Ile Ser Asp Gly Lys	
610 615 620	
tta aat gag ggc cac aca ttg gac atg gat ctt gtt ttt ctc ttt gac	1920
Leu Asn Glu Gly His Thr Leu Asp Met Asp Leu Val Phe Leu Phe Asp	
625 630 635 640	

aac agt aaa atc acc tat gag act cag atc tcc cca cgg ccc caa cct Asn Ser Lys Ile Thr Tyr Glu Thr Gln Ile Ser Pro Arg Pro Gln Pro 645 650 655	1968
gaa agt gtc agc tgt atc ctt caa gag ccc aag agg aat ctc gcc ttc Glu Ser Val Ser Cys Ile Leu Gln Glu Pro Lys Arg Asn Leu Ala Phe 660 665 670	2016
ttc cag ctg agg aag gtg tgg ggc cag gtc tgg cac agc atc cag acc Phe Gln Leu Arg Lys Val Trp Gly Gln Val Trp His Ser Ile Gln Thr 675 680 685	2064
ctg aag gaa gat tgc aac cgg ctg cag cag gga cag cga gcc gcc atg Leu Lys Glu Asp Cys Asn Arg Leu Gln Gln Gly Gln Arg Ala Ala Met 690 695 700	2112
atg aat ctc ctc cga aac aac agc tgc ctc tcc aaa atg aag aat tcc Met Asn Leu Leu Arg Asn Asn Ser Cys Leu Ser Lys Met Lys Asn Ser 705 710 715 720	2160
atg gct tcc atg tct cag cag ctc aag gcc aag ttg gat ttc ttc aaa Met Ala Ser Met Ser Gln Gln Leu Lys Ala Lys Leu Asp Phe Phe Lys 725 730 735	2208
acc agc atc cag att gac ctg gag aag tac agc gag caa acc gag ttt Thr Ser Ile Gln Ile Asp Leu Glu Lys Tyr Ser Glu Gln Thr Glu Phe 740 745 750	2256
ggg atc aca tca gat aaa ctg ctg ctg gcc tgg agg gaa atg gag cag Gly Ile Thr Ser Asp Lys Leu Leu Leu Ala Trp Arg Glu Met Glu Gln 755 760 765	2304
gct gtg gag ctc tgt ggg cgg gag aac gaa gtg aaa ctc ctg gta gaa Ala Val Glu Leu Cys Gly Arg Glu Asn Glu Val Lys Leu Leu Val Glu 770 775 780	2352
cgg atg atg gct ctg cag acc gac att gtg gac tta cag agg agc ccc Arg Met Met Ala Leu Gln Thr Asp Ile Val Asp Leu Gln Arg Ser Pro 785 790 795 800	2400
atg ggc cgg aag cag ggg gga acg ctg gac gac cta gag gag caa gca Met Gly Arg Lys Gln Gly Gly Thr Leu Asp Asp Leu Glu Glu Gln Ala 805 810 815	2448
agg gag ctg tac agg aga cta agg gaa aaa cct cga gac cag cga act Arg Glu Leu Tyr Arg Arg Leu Arg Glu Lys Pro Arg Asp Gln Arg Thr 820 825 830	2496
gag ggt gac agt cag gaa atg gta cgg ctg ctg ctt cag gca att cag Glu Gly Asp Ser Gln Glu Met Val Arg Leu Leu Leu Gln Ala Ile Gln 835 840 845	2544
agc ttc gag aag aaa gtg cga gtg atc tat acg cag ctc agt aaa act Ser Phe Glu Lys Lys Val Arg Val Ile Tyr Thr Gln Leu Ser Lys Thr 850 855 860	2592
gtg gtt tgc aag cag aag gcg ctg gaa ctg ttg ccc aag gtg gaa gag Val Val Cys Lys Gln Lys Ala Leu Glu Leu Leu Pro Lys Val Glu Glu 865 870 875 880	2640

gtg gtg agc tta atg aat gag gat gag aag act gtt gtc cgg ctg cag 2688  
 Val Val Ser Leu Met Asn Glu Asp Glu Lys Thr Val Val Arg Leu Gln  
 885 890 895  
 gag aag cgg cag aag gag ctc tgg aat ctc ctg aag att gct tgt agc 2736  
 Glu Lys Arg Gln Lys Glu Leu Trp Asn Leu Leu Lys Ile Ala Cys Ser  
 900 905 910  
 aag gtc cgt ggt cct gtc agt gga agc ccg gat agc atg aat gcc tct 2784  
 Lys Val Arg Gly Pro Val Ser Gly Ser Pro Asp Ser Met Asn Ala Ser  
 915 920 925  
 cga ctt agc cag cct ggg cag ctg atg tct cag ccc tcc acg gcc tcc 2832  
 Arg Leu Ser Gln Pro Gly Gln Leu Met Ser Gln Pro Ser Thr Ala Ser  
 930 935 940  
 aac agc tta cct gag cca gcc aag aag agt gaa gaa ctg gtg gct gaa 2880  
 Asn Ser Leu Pro Glu Pro Ala Lys Lys Ser Glu Glu Leu Val Ala Glu  
 945 950 955 960  
 gca cat aac ctc tgc acc ctg cta gaa aat gcc ata cag gac act gtg 2928  
 Ala His Asn Leu Cys Thr Leu Leu Glu Asn Ala Ile Gln Asp Thr Val  
 965 970 975  
 agg gaa caa gac cag agt ttc acg gcc cta gac tgg agc tgg tta cag 2976  
 Arg Glu Gln Asp Gln Ser Phe Thr Ala Leu Asp Trp Ser Trp Leu Gln  
 980 985 990  
 acg gaa gaa gaa gag cac agc tgc ctg gag cag gcc tca tga 3018  
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&lt;211&gt; 1005

&lt;212&gt; PRT

<213> *Aequorea victoria* and human

&lt;400&gt; 14

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 20 25 30  
 Glu Gly Glu Gly Asp Ala Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile  
 35 40 45  
 Cys Thr Thr Gly Lys Leu Pro Val Pro Trp Pro Thr Leu Val Thr Thr  
 50 55 60  
 Leu Thr Tyr Gly Val Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys  
 65 70 75 80  
 Gln His Asp Phe Phe Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu  
 85 90 95  
 Arg Thr Ile Phe Phe Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu  
 100 105 110  
 Val Lys Phe Glu Gly Asp Thr Leu Val Asn Arg Ile Glu Leu Lys Gly  
 115 120 125  
 Ile Asp Phe Lys Glu Asp Gly Asn Ile Leu Gly His Lys Leu Glu Tyr  
 130 135 140  
 Asn Tyr Asn Ser His Asn Val Tyr Ile Met Ala Asp Lys Gln Lys Asn

145 150 155 160  
 Gly Ile Lys Val Asn Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser  
 165 170 175  
 Val Gln Leu Ala Asp His Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly  
 180 185 190  
 Pro Val Leu Leu Pro Asp Asn His Tyr Leu Ser Thr Gln Ser Ala Leu  
 195 200 205  
 Ser Lys Asp Pro Asn Glu Lys Arg Asp His Met Val Leu Leu Glu Phe  
 210 215 220  
 Val Thr Ala Ala Gly Ile Thr Leu Gly Met Asp Glu Leu Tyr Lys Ser  
 225 230 235 240  
 Gly Leu Arg Ser Arg Ala Gln Ala Tyr Met Ser Trp Ser Pro Ser Leu  
 245 250 255  
 Thr Thr Gln Thr Cys Gly Ala Trp Glu Met Lys Glu Arg Leu Gly Thr  
 260 265 270  
 Gly Gly Phe Gly Asn Val Ile Arg Trp His Asn Gln Glu Thr Gly Glu  
 275 280 285  
 Gln Ile Ala Ile Lys Gln Cys Arg Gln Glu Leu Ser Pro Arg Asn Arg  
 290 295 300  
 Glu Arg Trp Cys Leu Glu Ile Gln Ile Met Arg Arg Leu Thr His Pro  
 305 310 315 320  
 Asn Val Val Ala Ala Arg Asp Val Pro Glu Gly Met Gln Asn Leu Ala  
 325 330 335  
 Pro Asn Asp Leu Pro Leu Leu Ala Met Glu Tyr Cys Gln Gly Gly Asp  
 340 345 350  
 Leu Arg Lys Tyr Leu Asn Gln Phe Glu Asn Cys Cys Gly Leu Arg Glu  
 355 360 365  
 Gly Ala Ile Leu Thr Leu Leu Ser Asp Ile Ala Ser Ala Leu Arg Tyr  
 370 375 380  
 Leu His Glu Asn Arg Ile Ile His Arg Asp Leu Lys Pro Glu Asn Ile  
 385 390 395 400  
 Val Leu Gln Gln Gly Glu Gln Arg Leu Ile His Lys Ile Ile Asp Leu  
 405 410 415  
 Gly Tyr Ala Lys Glu Leu Asp Gln Gly Ser Leu Cys Thr Ser Phe Val  
 420 425 430  
 Gly Thr Leu Gln Tyr Leu Ala Pro Glu Leu Leu Glu Gln Gln Lys Tyr  
 435 440 445  
 Thr Val Thr Val Asp Tyr Trp Ser Phe Gly Thr Leu Ala Phe Glu Cys  
 450 455 460  
 Ile Thr Gly Phe Arg Pro Phe Leu Pro Asn Trp Gln Pro Val Gln Trp  
 465 470 475 480  
 His Ser Lys Val Arg Gln Lys Ser Glu Val Asp Ile Val Val Ser Glu  
 485 490 495  
 Asp Leu Asn Gly Thr Val Lys Phe Ser Ser Ser Leu Pro Tyr Pro Asn  
 500 505 510  
 Asn Leu Asn Ser Val Leu Ala Glu Arg Leu Glu Lys Trp Leu Gln Leu  
 515 520 525  
 Met Leu Met Trp His Pro Arg Gln Arg Gly Thr Asp Pro Thr Tyr Gly  
 530 535 540  
 Pro Asn Gly Cys Phe Lys Ala Leu Asp Asp Ile Leu Asn Leu Lys Leu  
 545 550 555 560  
 Val His Ile Leu Asn Met Val Thr Gly Thr Ile His Thr Tyr Pro Val  
 565 570 575  
 Thr Glu Asp Glu Ser Leu Gln Ser Leu Lys Ala Arg Ile Gln Gln Asp  
 580 585 590  
 Thr Gly Ile Pro Glu Glu Asp Gln Glu Leu Leu Gln Glu Ala Gly Leu  
 595 600 605  
 Ala Leu Ile Pro Asp Lys Pro Ala Thr Gln Cys Ile Ser Asp Gly Lys  
 610 615 620

Leu Asn Glu Gly His Thr Leu Asp Met Asp Leu Val Phe Leu Phe Asp  
 625 630 635 640  
 Asn Ser Lys Ile Thr Tyr Glu Thr Gln Ile Ser Pro Arg Pro Gln Pro  
 645 650 655  
 Glu Ser Val Ser Cys Ile Leu Gln Glu Pro Lys Arg Asn Leu Ala Phe  
 660 665 670  
 Phe Gln Leu Arg Lys Val Trp Gly Gln Val Trp His Ser Ile Gln Thr  
 675 680 685  
 Leu Lys Glu Asp Cys Asn Arg Leu Gln Gln Gly Gln Arg Ala Ala Met  
 690 695 700  
 Met Asn Leu Leu Arg Asn Asn Ser Cys Leu Ser Lys Met Lys Asn Ser  
 705 710 715 720  
 Met Ala Ser Met Ser Gln Gln Leu Lys Ala Lys Leu Asp Phe Phe Lys  
 725 730 735  
 Thr Ser Ile Gln Ile Asp Leu Glu Lys Tyr Ser Glu Gln Thr Glu Phe  
 740 745 750  
 Gly Ile Thr Ser Asp Lys Leu Leu Leu Ala Trp Arg Glu Met Glu Gln  
 755 760 765  
 Ala Val Glu Leu Cys Gly Arg Glu Asn Glu Val Lys Leu Leu Val Glu  
 770 775 780  
 Arg Met Met Ala Leu Gln Thr Asp Ile Val Asp Leu Gln Arg Ser Pro  
 785 790 795 800  
 Met Gly Arg Lys Gln Gly Gly Thr Leu Asp Asp Leu Glu Glu Gln Ala  
 805 810 815  
 Arg Glu Leu Tyr Arg Arg Leu Arg Glu Lys Pro Arg Asp Gln Arg Thr  
 820 825 830  
 Glu Gly Asp Ser Gln Glu Met Val Arg Leu Leu Leu Gln Ala Ile Gln  
 835 840 845  
 Ser Phe Glu Lys Lys Val Arg Val Ile Tyr Thr Gln Leu Ser Lys Thr  
 850 855 860  
 Val Val Cys Lys Gln Lys Ala Leu Glu Leu Leu Pro Lys Val Glu Glu  
 865 870 875 880  
 Val Val Ser Leu Met Asn Glu Asp Glu Lys Thr Val Val Arg Leu Gln  
 885 890 895  
 Glu Lys Arg Gln Lys Glu Leu Trp Asn Leu Leu Lys Ile Ala Cys Ser  
 900 905 910  
 Lys Val Arg Gly Pro Val Ser Gly Ser Pro Asp Ser Met Asn Ala Ser  
 915 920 925  
 Arg Leu Ser Gln Pro Gly Gln Leu Met Ser Gln Pro Ser Thr Ala Ser  
 930 935 940  
 Asn Ser Leu Pro Glu Pro Ala Lys Lys Ser Glu Glu Leu Val Ala Glu  
 945 950 955 960  
 Ala His Asn Leu Cys Thr Leu Leu Glu Asn Ala Ile Gln Asp Thr Val  
 965 970 975  
 Arg Glu Gln Asp Gln Ser Phe Thr Ala Leu Asp Trp Ser Trp Leu Gln  
 980 985 990  
 Thr Glu Glu Glu Glu His Ser Cys Leu Glu Gln Ala Ser  
 995 1000 1005

<210> 15  
 <211> 1659  
 <212> DNA  
 <213> *Aequorea victoria* and human

<220>  
 <221> CDS  
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<400> 15

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gtc gag ctg gac ggc gac gta aac ggc cac aag ttc agc gtc tcc ggc	96
Val Glu Leu Asp Gly Asp Val Asn Gly His Lys Phe Ser Val Ser Gly	
20 25 30	
gag ggc gag ggc gat gcc acc tac ggc aag ctg acc ctg aag ttc atc	144
Glu Gly Glu Gly Asp Ala Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile	
35 40 45	
tgc acc acc ggc aag ctg ccc gtc ccc tgg ccc acc ctc gtc acc acc	192
Cys Thr Thr Gly Lys Leu Pro Val Pro Trp Pro Thr Leu Val Thr Thr	
50 55 60	
ctg acc tac ggc gtc cag tgc ttc agc cgc tac ccc gac cac atg aag	240
Leu Thr Tyr Gly Val Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys	
65 70 75 80	
cag cac gac ttc ttc aag tcc gcc atg ccc gaa ggc tac gtc cag gag	288
Gln His Asp Phe Phe Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu	
85 90 95	
cgc acc atc ttc ttc aag gac gac ggc aac tac aag acc cgc gcc gag	336
Arg Thr Ile Phe Phe Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu	
100 105 110	
gtg aag ttc gag ggc gac acc ctg gtc aac cgc atc gag ctg aag ggc	384
Val Lys Phe Glu Gly Asp Thr Leu Val Asn Arg Ile Glu Leu Lys Gly	
115 120 125	
atc gac ttc aag gag gac ggc aac atc ctg ggc cac aag ctg gag tac	432
Ile Asp Phe Lys Glu Asp Gly Asn Ile Leu Gly His Lys Leu Glu Tyr	
130 135 140	
aac tac aac agc cac aac gtc tat atc atg gcc gac aag cag aag aac	480
Asn Tyr Asn Ser His Asn Val Tyr Ile Met Ala Asp Lys Gln Lys Asn	
145 150 155 160	
ggc atc aag gtc aac ttc aag atc cgc cac aac atc gag gac ggc agc	528
Gly Ile Lys Val Asn Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser	
165 170 175	
gtg cag ctc gcc gac cac tac cag cag aac acc ccc atc ggc gac ggc	576
Val Gln Leu Ala Asp His Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly	
180 185 190	
ccc gtc ctg ctg ccc gac aac cac tac ctg agc acc cag tcc gcc ctg	624
Pro Val Leu Leu Pro Asp Asn His Tyr Leu Ser Thr Thr Ser Ala Leu	
195 200 205	
agc aaa gac ccc aac gag aag cgc gat cac atg gtc ctg ctg gag ttc	672
Ser Lys Asp Pro Asn Glu Lys Arg Asp His Met Val Leu Leu Glu Phe	
210 215 220	
gtg acc gcc gcc ggc atc act ctc ggc atg gac gag ctg tac aag tcc	720
Val Thr Ala Ala Gly Ile Thr Leu Gly Met Asp Glu Leu Tyr Lys Ser	
225 230 235 240	

gga ctc aga tct cga gct caa gct tcc acc atg atg aat ctc ctc cga Gly Leu Arg Ser Arg Ala Gln Ala Ser Thr Met Met Asn Leu Leu Arg 245 250 255	768
aac aac agc tgc ctc tcc aaa atg aag aat tcc atg gct tcc atg tct Asn Asn Ser Cys Leu Ser Lys Met Lys Asn Ser Met Ala Ser Met Ser 260 265 270	816
cag cag ctc aag gcc aag ttg gat ttc ttc aaa acc agc atc cag att Gln Gln Leu Lys Ala Lys Leu Asp Phe Phe Lys Thr Ser Ile Gln Ile 275 280 285	864
gac ctg gag aag tac agc gag caa acc gag ttt ggg atc aca tca gat Asp Leu Glu Lys Tyr Ser Glu Gln Thr Glu Phe Gly Ile Thr Ser Asp 290 295 300	912
aaa ctg ctg ctg gcc tgg agg gaa atg gag cag gct gtg gag ctc tgt Lys Leu Leu Leu Ala Trp Arg Glu Met Glu Gln Ala Val Glu Leu Cys 305 310 315 320	960
ggg cgg gag aac gaa gtg aaa ctc ctg gta gaa cgg atg atg gct ctg Gly Arg Glu Asn Glu Val Lys Leu Leu Val Glu Arg Met Met Ala Leu 325 330 335	1008
cag acc gac att gtg gac tta cag agg agc ccc atg ggc cgg aag cag Gln Thr Asp Ile Val Asp Leu Gln Arg Ser Pro Met Gly Arg Lys Gln 340 345 350	1056
ggg gga acg ctg gac gac cta gag gag caa gca agg gag ctg tac agg Gly Gly Thr Leu Asp Asp Leu Glu Glu Gln Ala Arg Glu Leu Tyr Arg 355 360 365	1104
aga cta agg gaa aaa cct cga gac cag cga act gag ggt gac agt cag Arg Leu Arg Glu Lys Pro Arg Asp Gln Arg Thr Glu Gly Asp Ser Gln 370 375 380	1152
gaa atg gta cgg ctg ctg ctt cag gca att cag agc ttc gag aag aaa Glu Met Val Arg Leu Leu Leu Gln Ala Ile Gln Ser Phe Glu Lys Lys 385 390 395 400	1200
gtg cga gtg atc tat acg cag ctc agt aaa act gtg gtt tgc aag cag Val Arg Val Ile Tyr Thr Gln Leu Ser Lys Thr Val Val Cys Lys Gln 405 410 415	1248
aag cgc ctg gaa ctg ttg ccc aag gtg gaa gag gtg gtg agc tta atg Lys Ala Leu Glu Leu Leu Pro Lys Val Glu Glu Val Val Ser Leu Met 420 425 430	1296
aat gag gat gag aag act gtt gtc cgg ctg cag gag aag cgg cag aag Asn Glu Asp Glu Lys Thr Val Val Arg Leu Gln Glu Lys Arg Gln Lys 435 440 445	1344
gag ctc tgg aat ctc ctg aag att gct tgt agc aag gtc cgt ggt cct Glu Leu Trp Asn Leu Leu Lys Ile Ala Cys Ser Lys Val Arg Gly Pro 450 455 460	1392
gtc agt gga agc ccg gat agc atg aat gcc tct cga ctt agc cag cct Val Ser Gly Ser Pro Asp Ser Met Asn Ala Ser Arg Leu Ser Gln Pro	1440

465	470	475	480	
ggg cag ctg atg tct cag ccc tcc acg gcc tcc aac agc tta cct gag				1488
Gly Gln Leu Met Ser Gln Pro Ser Thr Ala Ser Asn Ser Leu Pro Glu				
	485	490	495	
cca gcc aag aag agt gaa gaa ctg gtg gct gaa gca cat aac ctc tgc				1536
Pro Ala Lys Lys Ser Glu Glu Leu Val Ala Glu Ala His Asn Leu Cys				
	500	505	510	
acc ctg cta gaa aat gcc ata cag gac act gtg agg gaa caa gac cag				1584
Thr Leu Leu Glu Asn Ala Ile Gln Asp Thr Val Arg Glu Gln Asp Gln				
	515	520	525	
agt ttc acg gcc cta gac tgg agc tgg tta cag acg gaa gaa gaa gag				1632
Ser Phe Thr Ala Leu Asp Trp Ser Trp Leu Gln Thr Glu Glu Glu Glu				
	530	535	540	
cac agc tgc ctg gag cag gcc tca tga				1659
His Ser Cys Leu Glu Gln Ala Ser *				
	545	550		

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 <211> 552  
 <212> PRT  
 <213> Aequorea victoria and human

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 Glu Gly Glu Gly Asp Ala Thr Tyr Gly Lys Leu Thr Leu Lys Phe Ile  
 35 40 45  
 Cys Thr Thr Gly Lys Leu Pro Val Pro Trp Pro Thr Leu Val Thr Thr  
 50 55 60  
 Leu Thr Tyr Gly Val Gln Cys Phe Ser Arg Tyr Pro Asp His Met Lys  
 65 70 75 80  
 Gln His Asp Phe Phe Lys Ser Ala Met Pro Glu Gly Tyr Val Gln Glu  
 85 90 95  
 Arg Thr Ile Phe Phe Lys Asp Asp Gly Asn Tyr Lys Thr Arg Ala Glu  
 100 105 110  
 Val Lys Phe Glu Gly Asp Thr Leu Val Asn Arg Ile Glu Leu Lys Gly  
 115 120 125  
 Ile Asp Phe Lys Glu Asp Gly Asn Ile Leu Gly His Lys Leu Glu Tyr  
 130 135 140  
 Asn Tyr Asn Ser His Asn Val Tyr Ile Met Ala Asp Lys Gln Lys Asn  
 145 150 155 160  
 Gly Ile Lys Val Asn Phe Lys Ile Arg His Asn Ile Glu Asp Gly Ser  
 165 170 175  
 Val Gln Leu Ala Asp His Tyr Gln Gln Asn Thr Pro Ile Gly Asp Gly  
 180 185 190  
 Pro Val Leu Leu Pro Asp Asn His Tyr Leu Ser Thr Gln Ser Ala Leu  
 195 200 205  
 Ser Lys Asp Pro Asn Glu Lys Arg Asp His Met Val Leu Leu Glu Phe  
 210 215 220  
 Val Thr Ala Ala Gly Ile Thr Leu Gly Met Asp Glu Leu Tyr Lys Ser  
 225 230 235 240

Gly Leu Arg Ser Arg Ala Gln Ala Ser Thr Met Met Asn Leu Leu Arg  
 245 250 255  
 Asn Asn Ser Cys Leu Ser Lys Met Lys Asn Ser Met Ala Ser Met Ser  
 260 265 270  
 Gln Gln Leu Lys Ala Lys Leu Asp Phe Phe Lys Thr Ser Ile Gln Ile  
 275 280 285  
 Asp Leu Glu Lys Tyr Ser Glu Gln Thr Glu Phe Gly Ile Thr Ser Asp  
 290 295 300  
 Lys Leu Leu Leu Ala Trp Arg Glu Met Glu Gln Ala Val Glu Leu Cys  
 305 310 315 320  
 Gly Arg Glu Asn Glu Val Lys Leu Leu Val Glu Arg Met Met Ala Leu  
 325 330 335  
 Gln Thr Asp Ile Val Asp Leu Gln Arg Ser Pro Met Gly Arg Lys Gln  
 340 345 350  
 Gly Gly Thr Leu Asp Asp Leu Glu Glu Gln Ala Arg Glu Leu Tyr Arg  
 355 360 365  
 Arg Leu Arg Glu Lys Pro Arg Asp Gln Arg Thr Glu Gly Asp Ser Gln  
 370 375 380  
 Glu Met Val Arg Leu Leu Leu Gln Ala Ile Gln Ser Phe Glu Lys Lys  
 385 390 395 400  
 Val Arg Val Ile Tyr Thr Gln Leu Ser Lys Thr Val Val Cys Lys Gln  
 405 410 415  
 Lys Ala Leu Glu Leu Leu Pro Lys Val Glu Glu Val Val Ser Leu Met  
 420 425 430  
 Asn Glu Asp Glu Lys Thr Val Val Arg Leu Gln Glu Lys Arg Gln Lys  
 435 440 445  
 Glu Leu Trp Asn Leu Leu Lys Ile Ala Cys Ser Lys Val Arg Gly Pro  
 450 455 460  
 Val Ser Gly Ser Pro Asp Ser Met Asn Ala Ser Arg Leu Ser Gln Pro  
 465 470 475 480  
 Gly Gln Leu Met Ser Gln Pro Ser Thr Ala Ser Asn Ser Leu Pro Glu  
 485 490 495  
 Pro Ala Lys Lys Ser Glu Glu Leu Val Ala Glu Ala His Asn Leu Cys  
 500 505 510  
 Thr Leu Leu Glu Asn Ala Ile Gln Asp Thr Val Arg Glu Gln Asp Gln  
 515 520 525  
 Ser Phe Thr Ala Leu Asp Trp Ser Trp Leu Gln Thr Glu Glu Glu Glu  
 530 535 540  
 His Ser Cys Leu Glu Gln Ala Ser  
 545 550